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INTRASPECIFIC VARIATION IN SNAKE VENOM: CAUSES AND CONSEQUENCES

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ABSTRACT.- The degree and pattern of intraspecific variation in venom both within and between populations is examined in the light of ecological and evolutionary reasons for the occurrence and maintenance of this variation. Within a population, venom variability is proposed to result primarily from intrinsic factors of genotype, age and sex, since there is little evidence of phenotypic plasticity caused by extrinsic factors such as season and diet. Between populations, the differences in venom composition are proposed to be a result of genetic drift subsequent to reproductive isolation, the presence of cryptic species-complexes, and predator-prey coevolution in different local environments. The implications of intraspecific venom variation to the treatment of snake bite and to the use of venom composition as a research and taxonomic tool are discussed.

KEY WORDS: Snake, venom, intraspecific variation, taxonomy.

INTRODUCTION

The function of venom in snakes is primarily to immobilize or kill prey and secondarily, to aid in its digestion. To achieve this, venoms contain a complex mixture of neurotoxic (pre/post synaptic), cardiotoxic, myolytic, coagulant (anticoagulant), haemostatic (activating/inhibiting), and haemorrhagic factors in combination with proteolytic and hydrolytic enzymes (Chippaux *et al.*, 1991). Since the prey composition of snakes vary, it is hypothesised that each species will have its own particular requirement for the action of venom. Consequently, venom composition may be determined by both the foraging and dietary requirements as well as the phylogenetic and evolutionary history of a species.

Venom variation between families, genera, and species is well documented in the literature (Kochva, 1987; Chippaux *et al.*, 1991). Intraspecific venom variation has also been recorded in almost all genera of venomous snakes (Chippaux *et al.*, 1991). However, the reasons for the maintenance of this variability within species has been given little attention. The first section of this paper examines the potential causes of venom variation within a freely interbreeding population, and the second section examines venom variation between isolated populations and clinal variation.

DISCUSSION

Intrapopulation venom variation: Variation in venom composition within an inter-breeding population may be either due to intrinsic factors of the snake (genotype, ontogeny, sex), or due to extrinsic factors (season, diet and habitat).

Intrinsic factors- Genotype: It has been demonstrated that 15 different isoforms of crotoxin in *Crotalus durissus terrificus* venom result from the expression of different isogenes (Faure and Bon, 1987). Based on inter-generational and sibling studies, the genetic origin of variability has also been demonstrated in venom toxin content in *Crotalus adamanteus* (Mebs and Kornalik, 1984), in the pathophysiological and enzymatic activity of venom in *Bothrops asper* (Taborska and Kornalik, 1985), and in the coagulant activity of venom in *Bothrops asper* and *Vipera russelii* (Kornalik and Taborska, 1988).

Intensive fractionation of some cobra and sea snake venoms indicate that venom may contain more than 25 different proteins (5 per cent of total protein content). Given the large number of proteins and peptides present, it is possible that at least some of the variation is simply the expression of the ubiquitous genetic variation found within all populations. However, the reasons for the existence of multiple copies of toxins and enzymes within an individual, and the reasons for the exist-

ence and maintenance of multiple alleles within a population, are a matter of current debate (Kochva, 1987; Chippaux *et al.*, 1991).

Ontogenetic factors: Although several studies have documented ontogenetic changes in composition and properties of venom, there seems to be no consistent pattern to these differences. In the genus *Crotalus*, for example, toxicity (LD_{50} on laboratory mice) was found to decrease with age and level off at maturity in the majority of cases (Fiero *et al.*, 1972; Bonilla *et al.*, 1973; Reid and Theakston, 1978; Meier and Freyvogel, 1980; Mackessy, 1988). However, in some studies on *Crotalus atrox* lethality peaked at 6-8 months of age and then leveled off at 12-18 months (Minton, 1957; 1967).

In *Bothrops erythromelas*, *B. jararaca*, *B. jararacussu*, *B. moojeni*, *B. neuwiedi paranaensis* and *B. neuwiedi pauloensis* venom from new born snakes was less toxic than adult venom, but the pattern was reversed in *B. alternatus* and *B. cotiara* (Furtado *et al.*, 1991). The above study also found significant differences between adults and newborns in the protein content, electrophoretic banding, amidolytic activity, plasma coagulant activity, factor X, and prothrombin activation. Again, there was no consistent pattern to these differences. Even within a given species (*Crotalus v. viridis*) some studies have shown conspicuous ontogenetic difference in protein banding of venom (Minton, 1967, Lomonte *et al.*, 1983, Meier, 1986, Gutirrez *et al.*, 1990), while others have found no qualitative differences (Friero *et al.*, 1972).

Coagulant activity appears to decrease with age in *Crotalus h. horridus* (Bonilla *et al.*, 1973), *Bothrops moojeni* (Furtado and Kamiguti, 1985), *Bothrops jararaca* (Kamiguti and Hanada, 1985), *Lachesis muta stenophrys* (Gutierrez *et al.*, 1990). Proteolytic activity, on the other hand, was generally found to increase with age (*Crotalus atrox*, Theakston and Reid, 1978; Minton and Weinstein, 1986; *Crotalus viridis helleri* and *C. v. oreganus*, Mackessy, 1988).

The functional significance of these ontogenetic changes in venom composition remains unclear. It has been suggested that the higher toxicity of juvenile venom compensates for the smaller quantity produced (Mackessey, 1988; Hayes, 1991), but it is unclear why increasing venom production should select for lower toxicity. It is known that the diet of snakes changes with age, and that the size of the prey corresponds roughly to the size of the snake (Fitch and Twining, 1946; Fitch, 1949; Klauber, 1972; Mushinsky, 1987; Mackessy, 1988; Macartney, 1989). Since the primary function of venom is to assist with the procurement of food (Klauber, 1972; Russell, 1980, 1984), it is hypothesized that ontogenetic change in venom composition should correlate with susceptibility of preferred prey species. Testing this hypothesis would require studies detailing the ontogenetic changes in the diet of a snake coincident with studies testing the efficiency of the venom on the different prey species.

Since, in addition to prey immobilization, venoms play a digestive role, it is possible that increased proteolytic activity of adult venoms aids in digestion of larger prey. It is also possible that the changes in the venom composition are due to developmental constraints. To date, the regulatory mechanism of ontogentic venom composition change has not been investigated.

Sexual factors: Most studies have not found any significant differences between the venoms of male and female snakes (Schenberg, 1959; Glenn and Straight, 1977; Williamse, 1978; Latifi, 1984). However, Marsh and Glatston (1974) noted that venom from female *Bitis nasicornis* contained an extra protein band absent in males. Similarly, Mebs and Kornalik (1984) found that in one litter of snakes only females expressed a basic toxin. However, it is possible that these results may be explained by individual variability alone due to limited sample sizes (Chippaux *et al.*, 1991).

Extrinsic factors: Although season, diet, and habitat have been suggested to influence venom components, the phenotypic plasticity of snake venom composition has not been specifically addressed.

Seasonality: Early in this century, numerous European physicians reported increased lethality of viper bites occurring in spring as compared to autumn (quoted in Chippaux *et al.*, 1991). However, more recent studies have failed to demonstrate any seasonal variations in venom from individual snakes milked at various periods

throughout a year (Boche *et al.*, 1981; Gregory *et al.*, 1984; Latifi, 1984; Gregory-Dwyer *et al.*, 1986).

Diet and habitat: Studies by Boche *et al.* (1981) and Gregory-Dwyer *et al.*, (1986) found that there was no modification in venom due to diet. However, in reviewing the literature it is evident that a conclusive study on phenotypic plasticity of venom components has not yet been carried out.

Interpopulation variation: On a larger geographic scale, venom variation has been documented both clinally and between isolated populations. The reasons that have been postulated for the existence of variation at this level are: genetic drift following reproductive isolation, the presence of hidden species complexes, and predator-prey coevolution in different habitats.

Reproductive isolation and genetic drift: The venoms of *Bothrops nummifera* and *Bothrops asper* from the Pacific coast have been found to be biochemically distinct from that of the Atlantic coast (Jimenez-Porras, 1964; Aragon-Ortiz and Gubensek, 1981; Moreno *et al.*, 1988). The evolution of this difference is thought to be due to the reproductive isolation of these populations by mountain ranges. Sadahiro and Omori-Satoh (1980) found that *Trimeresurus flavoviridis* from Okinawa Islands lacked a haemorrhagic fraction present in the morphologically indistinguishable snakes from Amami Oshima Islands, although venom composition within each group of islands was homogeneous (Tu *et al.*, 1980). Similarly, eleven island populations of *Notechis ater niger* differed significantly in electrophoretic protein banding pattern between islands but were homogeneous within each island (Williams and White 1987; Williams *et al.*, 1988). These patterns of variation were correlated to the geographic position of the populations and the time since separation of the populations.

The studies above found that while some proteins were conserved across all populations, many others were highly variable. It has been hypothesised that genetic drift should affect venom components with minor biological role while major toxin fractions should be conserved (Mebs and Kornalik, 1984). Unfortunately, testing the validity of this hypothesis would be difficult because the *in vivo* biological effects of many venom components in the specific prey of a given species is unknown. Also, some evidence of changes in major toxins has been reported which seems contrary to the above hypothesis (Mojave toxin in *Crotalus s. scutulatus*, Glenn and Straight, 1977 and *C. atrox*, Minton and Weinstein, 1986; haemorrhagic fraction in *T. flavoviridis* (Sadahiro and Omori-Satoh, 1980)). Consequently, although it appears that genetic drift contributes to intraspecific variation in venom components, its differential effect on the components of the venom remain unclear.

More intriguing however is the existence of clinal variation in venom composition where no obvious physical barrier currently exists. For example, the venom of *Crotalus s. scutulatus* from California, Utah, and southwestern Arizona contains Mojave toxin whereas venom from the Phoenix region contains little or no mojave toxin but exhibits greater proteolytic and haemorrhagic activity (Glenn *et al.*, 1983). There is currently no physical barriers between these populations and an inter-grade region has been described (Glenn and Straight, 1989). A similar clinal variation has been described for *Crotalus atrox* from Texas to Arizona (Minton and Weinstein, 1986). Similarly, in *Crotalus durrissus*, crotamine negative snakes predominated south of the 22nd parallel and east of the 49th meridian and to the north and west of these, only crotamine positive snakes were found (Schenberg, 1959).

Species complexes: It is possible that clinal variation as described above may correspond to the existence of hidden species complexes (i.e., morphologically indistinguishable but distinct species). For example, the geographic variation of toxin-alpha from *Naja nigricollis* appears to follow the species distribution within the former species complex (Chippaux *et al.*, 1991). The Asiatic cobras formerly considered as a single species (*Naja naja*) with ten subspecies, are now recognized as eight separate species (Wüster and Thorpe, 1990). Similarly, the African *Echis carinatus* are now considered as a group of separate species (Chippaux *et al.*, 1991). Both *Naja naja* and *Echis carinatus* complexes exhibit marked geographic variation in venom composition (Schaeffer, 1987). Unfortunately, interpretation of past research on venom differences within these complexes is uncertain since it is not always

possible to ascertain which species (as per the new classification) was used for the venom extraction. Interpretation of venom variation within the new taxonomic classifications should be forthcoming as more research is being done on these species complexes.

Predator-prey coevolution: The possible coevolution between venom components and resistance of prey species has not been well studied. In the venom of any one individual snake there are many isoforms of toxins and isozymes of enzymes, and an even greater variation is found within a population. Kochva (1987) has proposed that there may be a concomittant variation in the susceptibility of the prey to the various isozymes and isoforms of toxins. This variation could lead to a coevolutionary process with selection favouring higher resistance in prey and increased efficiency of venom in snakes.

The resistance of prey to different venoms may exhibit geographic variation. Also, the prey composition of a given species of snake may vary over its distribution range. Both these factors may lead to different venom components being favoured, which over time may lead to significant differences between populations. The possibility that ontogentic shifts in venom composition are to accomodate the changes in diet with age has been discussed above.

A further consideration is that, even within a specified location, different prey species are not all equally susceptible to different components of the venom. This may select for polymorphism in venom components to accomodate the varied diets of snakes. These possibilities are yet to be specifically investigated.

Consequences of intraspecific variation in venom composition: One of the most important consequences of intraspecific venom variation is in the treatment of snake bites. The disparity of symptoms in victims bitten by the same species of snakes is clinically well documented. The inefficiency of antivenom serum produced against venom collected from limited areas in treating snake bite in other areas is also well documented in the literature (Jimenez-Porras, 1964; Hardy, 1983; Jayanthi and Veerabasappa-Gowda, 1988; Warrell *et al.*, 1989; Wüster and Thorpe, 1991). The enormous intraspecific variation in venom components may explain these inconsistencies in symptoms and treatment. These findings highlight the need for local venom collection centers to provide a complete sampling of the intraspecific variation which would greatly aid in producing more efficient antivenom serum.

The presence of many enzymes and biologically active compounds in snake venom has recently made it an attractive tool in pharmacological and biochemical research. Therefore, knowledge of the geographic variation in the venom would not only enable the selection of a source rich in the component of interest, but also, ensure the consistency of the product when preparing pharmacologically active fractions from crude venoms.

The usefulness of venom composition as a taxonomic tool has been investigated by some researchers. It is recognized that there are common venom characteristics at the familial and generic levels (Bernadsky *et al.*, 1986; Tan and Gnanajothy, 1990). At the species level a new species of *Agkistrodon*, previously identified as *A. halys* (Pallas) was confirmed on the basis of venom analysis (Zhao, 1980). However, in a extensive study on the electrophoretic patterns of snake venoms in the genera *Bitis*, *Bothrops* and *Echis*, Tan and Gnanajothy (1992) concluded that venom variation has only limited taxonomic application at the species level due to marked intraspecific variation.

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DIETARY HABITS OF THE MUGGER (*CROCODYLUS PALUSTRIS*) IN ANDHRA PRADESH, SOUTH INDIA

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ABSTRACT.- Investigations were made on the dietary habits of the mugger (*Crocodylus palustris*) between October 1986 and May 1990. Of the 289 scat samples collected, 216 were of adults and 73 of subadults. Fish was found to be an important component of the diet in both size classes during all seasons of the year. However, mammals are also taken, especially by larger muggers.

KEY WORDS.- *Crocodylus palustris*, diet, seasonality, size-class, India.

INTRODUCTION

Dietary habit is one of the key aspects in assessing the role of crocodilians in the ecology of inland waters. Such studies not only provide a general picture of predator-prey relations, but also afford comparison between food habits of crocodiles of different size-classes. However, feeding strategies of Indian crocodiles have received little attention in the past.

There are few published reports on the food habits of the mugger, *Crocodylus palustris* (including those of Pitman, 1913; D'Abreu, 1915; McCann, 1935; Abdulali, 1938; Lewis, 1940; Battye, 1945), mostly on the basis of stomach content analysis of dead animals. Food habits have been studied by workers through the removal of stomach contents from crocodiles without sacrificing the animal (Tayler *et al.*, 1978). The sacrifice or capture of crocodilians in India for stomach content analysis is difficult as all crocodilians are protected under Schedule I of the Indian Wildlife (Protection) Act, 1972. Whitaker and Whitaker (1989) reported the food habits of the mugger in Tamil Nadu based on scat sample analysis.

The present paper details the food habits of subadult and adult muggers from direct observations and scat samples collected from three sites, Manjira, Ethypothala and Siwaram Wildlife Sanctuaries in Andhra Pradesh, south India. The aim of the study was to obtain information on the dietary habits of the mugger and to improve feeding strategies in captivity for enhancing management.

MATERIAL AND METHODS

Scat samples were collected from river banks between October, 1986 and May, 1990 and were classified into subadult and adult catagories based on their diameters (1.5 - 2.5 cm subadult; 3.5 - 5.5 cm adult) of the sample. The scat samples were soaked in water for 48 hours and the contents separated by passage through a set of sieves. The undigested food material that settled in each sieve was collected and identified. Prey types were identified from fragments of food remains, such as hair (mammals), feathers (birds), bones (reptiles and amphibians), scales (reptiles and fish), spines (fishes) and elytra and legs (insects).

RESULTS

A total of 289 scat samples were collected, of which 216 were of adults and 73 belonged to subadults. Table 1 shows the proportional occurrence of different categories of food items taken by subadult and adult muggers. It also shows an ontogenetic change in feeding pattern, with the larger individuals exhibiting a preference for large vertebrate prey. The subadults restrict themselves to smaller prey, including small fish, arthropods and amphibians, and only rarely take mammalian prey.

Apart from a diet dominated by fish, scat samples of subadults showed a high frequency of occurrence of arthropods and amphibians, that are presumably captured both under- and on the surface. The scat samples of adults showed the occurrence of mammals, reptiles and birds. These prey types are presumably captured by crocodiles lying

TABLE 1: Frequency occurrence of food items from scat samples of subadult and adult muggers.

Food items	Subadults (n = 73)		Adults (n = 216)	
	Frequency	% Frequency	Frequency	% Frequency
Mammals	5	6.85	96	44.44
Birds	1	1.37	9	4.16
Reptiles	2	2.74	11	5.09
Amphibians	13	24.65	26	12.03
Fish	49	67.12	148	68.52
Arthropods	43	58.90	23	10.64
Molluscs	4	5.47	4	1.85
Plants	0	0.00	6	2.77
Non-food material	0	0.00	3	1.38
Unidentifiable debris	6	8.22	11	5.09

TABLE 2: Food types of the mugger, and methods of estimation. x indicates presence.

Prey type	Identified from scat	Direct observation
MAMMALS		
1. Wild boar		x
2. Buffalo	x	x
3. Goat	x	
4. Sheep	x	
5. Wild hare	x	
6. Bandicoot	x	
7. Otter	x	
8. Domestic dog	x	
9. Field rat	x	
BIRDS		
10. Cormorant	x	
11. Purple moorhen	x	x
12. Egret	x	x
13. Coot	x	x
REPTILES		
14. Water snake	x	
15. Garden lizard	x	
16. Turtle	x	

TABLE 3: Seasonal changes in the dietary constituents of adult muggers.

Food items	Seasons					
	Winter (n = 75)		Summer (n = 120)		Monsoon (n = 21)	
	Freq	% Freq	Freq	% Freq	Freq	% Freq
Fish	46	61.33	84	70.00	18	85.71
Mammals	46	61.33	49	40.83	1	4.76
Birds	3	4.00	6	5.00	0	0.00
Arthropods	16	21.33	5	4.17	2	9.52
Amphibians	8	10.67	18	15.00	0	0.00

in ambush inshore or ashore.

The frequency of occurrence of mammals in the diet increases with the size in the mugger, from 6.85 per cent in subadults (n = 73) to 44.4 per cent in adults (n = 216). A number of wild and domesticated mammals, birds and reptiles are represented in the scat samples (Table 2). Evidence of predation on domestic livestock was found in 16 samples, although no direct observation was observed during the study. On one occasion, a mugger was observed feeding on the carcass of a domestic buffalo, which had died of unknown causes, in Manjira Wildlife Sanctuary. Local reports of mugger predation on domestic livestock at Ethipothalla Falls was confirmed from the recovery of sheep hair in five scat samples.

Adult muggers have often been observed fishing in open water during night surveys. Fish species identified through direct observations on such occasions include *Wallagu attu*, *Catla catla* and *Labeo potail*. At Manjira, muggers were observed taking birds, avian predation further supported by scat analysis: adult scats revealed the presence of little cormorant (*Phalacrocorax niger*), coot (*Fulica atra*) and cattle egret (*Bubulcus ibis*). An introduced subadult male was observed feeding on a purple moorhen (*Porphrio porphrio*) and a coot during the winter.

Seasonal variation in diet of adult muggers is shown in Table 3. Fish forms the mainstay of the diet during all the three seasons (winter, summer and monsoon). Mammals are taken more frequently, and gradually decrease in summer and the monsoon. Bird remains appear in scat samples during the winter and summer months. Amphibians are eaten during the summer and winter, whereas arthropod frequencies are found to be relatively high during the winter and low during the summer.

Fish forms the major constituent of the diet of subadults only during the summer (Table 4). Singh (1983) reported that intake of fish in subadults is reduced to less than 1per cent of body weight, fish having a conversion rate of 18.2 per cent. Increase in the occurrence of fish during the summer is suspected to be due to lowered water levels, which made capture easy. In winter, a variety of prey types, including arthropods, form a major portion of the diet and birds and mammals are taken only during the winter. However, during the monsoons, fish and arthropods were found almost in equal proportions.

DISCUSSION

Table 1 shows the food habits of the two size-classes of the mugger. Subadult muggers are limited to smaller prey, such as fish, arthropods and amphibians, and few mammalian prey were taken, possibly on account of size constraints and local prey abundance in the microhabitats utilized. D'Abreu (1915) recorded water beetles from the stomach of a 1.3 m subadult. Food has been shown to be an important factor that determines habitat usage by the different size-classes of crocodiles (Vijaya Kumar and Choudhury, 1990). Gaby *et al*. (1981; 1985) and Mazzotti (1983) observed that juveniles, subadults and adult crocodiles were found in different habitats. Thorbjarnarson (1984; 1989) also recorded the preference for marginal habitats by subadult crocodilians. Subadult muggers were primarily recorded from the shoreline and the generally associated areas with submerged vegetation. Prey taken by this size-class was fish fingerlings, insects, crabs, molluscs, amphibians, and during the winter, young birds, that are associated with such habitat. Table 2 shows that adults

TABLE 4: Seasonal changes in the dietary constituents of subadult muggers.

Food items	Seasons					
	Winter (n = 23)		Summer (n = 43)		Monsoon (n = 7)	
	Freq	% Freq	Freq	% Freq	Freq	% Freq
Fish	16	69.56	31	72.09	2	28.57
Mammals	5	21.74	0	0.00	0	0.00
Birds	1	4.35	0	0.00	0	0.00
Arthropods	22	95.65	19	44.10	2	28.57
Amphibians	8	10.67	18	15.00	0	0.00

feed on small insects, molluscs, amphibians, fish, reptiles, birds and large mammals. Fish, however, appears to be an important constituent of the diet for both size-classes, with the proportional contribution of this food type in the diet being similar.

These results compare with those obtained by Cott (1961) and McNease and Joanen (1981). The frequency of occurrence of mammals increases with ontogeny, being 6.85 per cent in the subadults (n = 73) and 44.44 per cent in the adults (n = 216). Games (1988) reported that mammals form the primary food of *Crocodylus niloticus* during the summer.

As basking is an important activity during the winter (Vijaya Kumar, 1993), greater activities on land during the day may also result in the mugger feeding more on land animals, such as mammals. Similar observations have been made by Tayler (1979), who found that individuals of *Crocodylus porosus* of snout-vent length over 4 feet ate more mammals and birds than smaller size-classes. McNease and Joanen (1981) reported that although excellent growth was achieved by captive *Alligator mississippiensis* on a diet of fish, the diet did not result in high reproductive success. It appears from the above that mammalian prey are required by muggers and other crocodilians for enhancing reproductive performance.

Evidence of predation on domestic livestock was recorded in 16 scat samples in the present study. Similar evidence by the mugger has been reported by Simcox (1905), Whitaker (1978) and Whitaker and Whitaker (1989). Although there are reports on human predation by the mugger by Pitman (1913), Krishnamurthy (1915), Bustard and Kar (1982) and Vyas (1993), no evidence was recorded during this study.

Tables 3 and 4 show that birds appear in the diet during the winter and summer relatively more frequently than during the monsoons. Large number of wintering birds have been recorded at Manjira (Vijaya Kumar and Choudhury, 1990). The concentration of birds presumably increases the prey base during the winter, between November and March/April.

MANAGEMENT IMPLICATIONS

Fish is an important component of the diet of subadult and adult muggers. Fish has a high content of crude protein and crude fat (McNease and Joanen, 1981) and also provides low intake and high conversion rate (Singh, 1983). However, fish alone may not be suitable diet for the high energy required during reproduction (McNease and Joanen, 1981). As observed in wild crocodiles, a mixed diet, including fish, mammals, birds and arthropods should be provided to captive crocodiles. Singh (1979) provided live pigeons for captive-reared muggers.

In most zoos and crocodile rearing centres in India, crocodiles are fed entirely on meat, which is both economical and easily available. However, a meat diet alone may not provide all the necessary nutrients required by the animal. In many rearing centres, crocodiles fed only on meat had hunchedbacks, probably due to a deficiency of calcium and Vitamin D in such a diet. This deficiency can be prevented by providing a diet of whole birds, including feathers, skin and bones and a supply of fish (Pillai, 1982), and it is recommended that at least once a week, fish and live birds should be provided to captive crocodiles.

ACKNOWLEDGEMENT

We are grateful to the Wildlife Institute of India, Dehra Dun for financial support. Our thanks are due to Andhra Pradesh Forest Department officials at Manjira, Ethipothala and Siwaram Wildlife Sanctuaries for support of the study. Thanks are also due to the Head, Department of Biosciences, Saurashtra University for support during the writing of this paper.

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A NEW SPECIES OF TREE FROG (GENUS *POLYPEDATES*) FROM GREAT NICOBAR, INDIA (ANURA: RHACOPHORIDAE)

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(with one plate and three text-figures)

ABSTRACT.- A new species of tree frog of the genus *Polypedates* is described on the basis of 11 examples collected from Great Nicobar Island, India. The new species is diagnosed by the following characteristics: large body size (female SVL ≤ 65.2 mm; male SVL ≤ 43.3 mm), head broader than long, and lacking a bony crest; concave lores; eye diameter less than the eye-nostril distance; tympanum diameter less than 3/4 eye diameter; toes 2/3 webbed; toe IV with one phalange free; absence of outer metatarsal tubercle; tibio-tarsal articulation reaches the nostrils; no tubercles on the undersurface of the arm and dorsum typically with a dark hour-glass marking.

KEY WORDS.- Anura; Rhacophoridae, *Polypedates insularis*; new species; Great Nicobar; India.

INTRODUCTION

The genus *Polypedates* Tschudi, 1838, was revived from the synonymy of *Rhacophorus* by Liem (1970), upon discovering a suite of anatomical and osteological characters that separate the two genera of Old World tree frogs. *Polypedates* contains species distributed over Sri Lanka and India, east to southern China and Japan and south to Indo-China and Indo-Malaya, including the Greater Sundas and the Philippines (Frost, 1985; Inger, 1966). Dubois (1986) doubted the validity of the genus, failing to discover consistent differences in phenetic characters, and tentatively assigned all Old World tree frogs back to the genus *Rhacophorus*, pending future systematic revision.

A series of 11 tree frogs collected from Great Nicobar Island, India, serves as the basis of the description of a new species of the genus. Features that agree with the definition of the genus *Polypedates* in Liem (1970) in the material include absence of dermal ornamentation; fingers webbed at the base; short parieto-squamosal arch; presence of vomerine teeth; large digital disks; usually with a dark hour-glass marking on dorsum and a dark transverse bar across the forehead. The species belongs to the *Rhacophorus leucomystax* group of Dubois (1986).

MATERIAL & METHODS

The 10 types obtained in 1994 were killed with chloroform, fixed in four per cent formalin and subsequently transferred to 70 per cent ethanol. The following measurements were taken with dial vernier caliper (to the nearest 0.1 mm): snout-vent length, SVL (from the tip of the snout to the vent); tibia length, TBL (tibia length, the distance between the surface of knee to the surface of heel, with both tibia and tarsus flexed); body width, BW (the greatest width of the trunk); head length, HL (the distance between the angle of the jaws and the snout-tip); head width, HW (measured at the angle of the jaws); eye diameter, ED (the diameter of the orbit); tympanum diameter, TYD (the greatest diameter of the tympanum); upper eyelid width, UE (the greatest width of the upper eyelid); interorbital width, IO (the least distance between the upper eyelids); eye to snout-tip distance, E-S (the distance between the anterior-most point of the eyes to the tip of the snout); eye to nostril distance, E-N (the distance between the anterior-most point of the eyes and the nostrils); fore limb length, FL (the length of the outstretched fore limb, from axilla to the tip of its longest finger); hind limb length, HIL (the length of the outstretched hind limbs, from vent to the tip of its longest toe); and F3D (width of disk on finger III).

Colour descriptions are made from Fujichrome

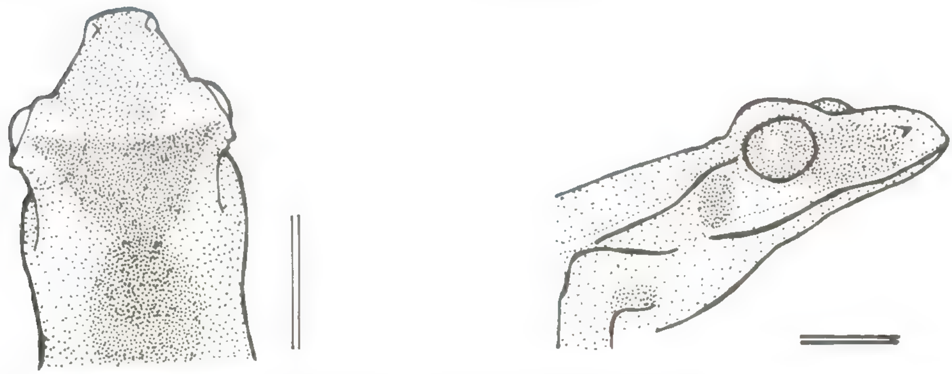


FIGURE 1: Dorsal (left) and lateral (right) views of head and nape of the holotype of *Polypedates insularis* sp. nov. (ZSI A8731). Markers represent 8 mm.

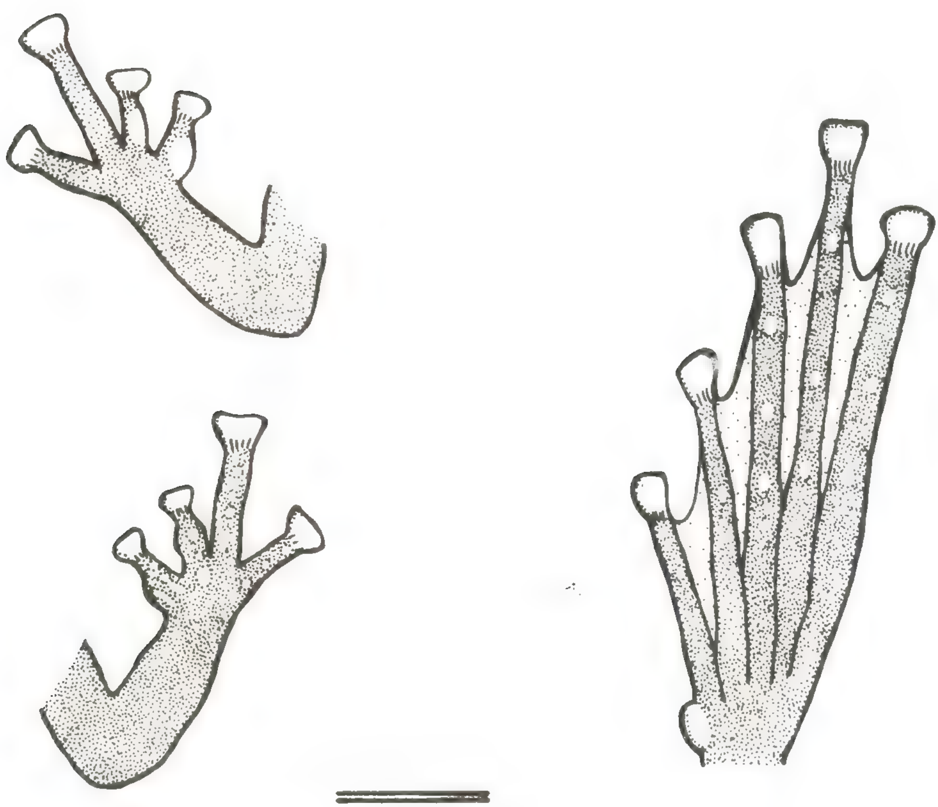
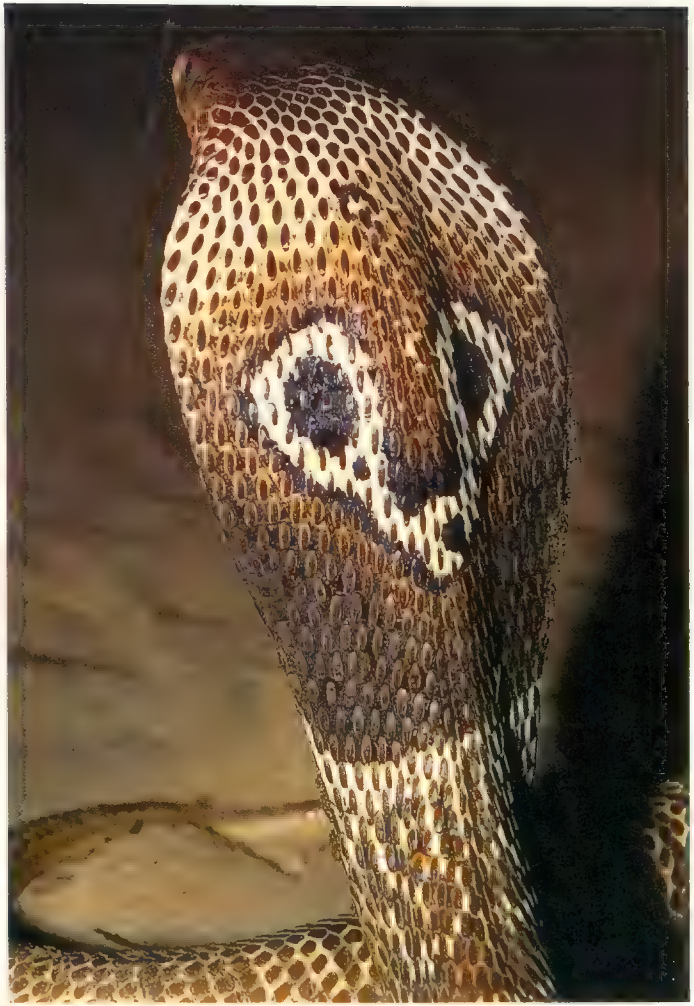


FIGURE 2: Dorsal (left top) and ventral (left bottom) views of the left fore limb and ventral view (right) of the left hind limb of the holotype of *Polypedates insularis* (ZSI A8731). Marker represents 6 mm.

PLATE 1

Paratype of *Polypedates insularis* sp. nov. (ZSI A8733) from Galathea National Park, Great Nicobar Island, India. Photo: Indraneil Das.



Spectacled cobra (*Naja naja*),
Madras, India. Photo: Romulus Whitaker.

Sri Lankan green pit viper (*Trimeresurus trigonocephalus*),
Sri Lanka. Photo: Indraneil Das.

100 ASA transparency film of the live types. Colour nomenclature follows Smith (1974; 1981).

Polypedates insularis sp. nov.
(Plate 1, Figs. 1—2)

Holotype: ZSI A8731. From circa 2 km E mouth of Galathea River, Galathea National Park, Great Nicobar, India. Collected by Indraneil Das and Satish Bhaskar. 12 March, 1994.

Paratopotypes: ZSI A8732, A8733 and A8734. From circa 2 km E mouth of Galathea River, Galathea National Park, Great Nicobar, India. Collected by Indraneil Das and Satish Bhaskar. 11 March, 1994.

Other paratypes: ZSI A8575. Campbell Bay, Great Nicobar, India. Collected by A. Daniel, H. K. Bhowmick, G. U. Kurup and party. 25.4.1966. ZSI A8735 and A8736. Shompen Hut, Great Nicobar, India. Collected by Indraneil Das and Satish Bhaskar. 17 March, 1994. ZSI A8737, A8738, A8739 and A8740. From circa 2 km E Kopen Heat (41 km point on the East-West Road), Great Nicobar, India. Collected by Indraneil Das and Satish Bhaskar. 18-22 March, 1994. All type localities have been indicated in Fig. 3.

Diagnosis: A large (female SVL $\leq$ 65.2 mm; male SVL $\leq$ 43.3 mm), differentiable from congeners from the Indo-Malayan region in possessing a head broader than long, and lacking a bony crest; concave lores; eye diameter less than the eye-nostril distance; tympanum diameter less than 3/4 eye diameter; toes 2/3 webbed; toe IV with one phalange free; absence of outer metatarsal tubercle; tibio-tarsal articulation reaches the nostrils; no tubercles on the undersurface of the arm and dorsum typically with a dark hour-glass marking.

Description of the type series: A medium-sized species of *Polypedates* (female SVL $\leq$ 65.2 mm; male SVL $\leq$ 43.3 mm). Habitus slender (BW/SVL ratios 0.206-0.345, mean 0.283 ± SE 0.014), with a narrow waist; head long (HL/SVL ratios 0.297-0.378, mean 0.327 ± SE 0.007) and broad (HW/SVL ratios 0.327-0.388, mean 0.349 ± SE 0.005), its width exceeding its length (HW/HL ratios 1.007-1.177, mean 1.070 ± SE 0.016). Snout obtusely oriented, slightly projecting; nostrils closer to the tip of snout than to the eyes (E-N/E-S ratios 0.619-0.726, mean 0.663 ± SE 0.010). Canthus rostralis vertical in transverse section; lores concave. Eyes large (ED/HL ratios 0.373-0.466, mean 0.417 ± SE 0.009); eye diameter less than the eye-nostril distance (ED/E-N ratios 1.026-1.364, mean 1.180 ± SE 0.032); interorbital distance slightly less than to greater than the upper eyelid width (IO/UE ratios 0.983-1.341, mean 1.140 ± SE 0.033). Pupil vertical. Supratympanic fold distinct, extending from the posterior corner of the upper eyelid, over the tympanum, to the insertion of the fore limbs, or occasionally, a little beyond. Tympanum distinct, its diameter less than 75 per cent eye diameter (TYD/ED ratios 0.458-0.597, mean 0.516 ± SE 0.015). Nostrils laterally oriented. Vomerine teeth in two oblique, contiguous series in the anterior half of the choanae, separated by a distance the length of each group. Inferior aspect of snout slightly nicked; inner margin of mandibles with a w-shaped notch. Tongue large, smooth, without papillae, elongated, bifid and free posteriorly for about 40 per cent of its length.

Fore limbs long (FL/SVL ratios 0.447-0.682, mean 0.557 ± SE 0.018); tips of fingers dilated into large, flattened, rounded disks with circummarginal grooves. Terminal phalanx Y-shaped. The largest disk (on finger III) is 3/4 to approximately x 1 time tympanum diameter (F3D/TYD ratios 0.633-1.023, mean 0.844 ± SE 0.034). Fingers webbed at the base, the most extensive webbing being between fingers I and II that fail to reach the first subarticular tubercle. Distal subdigital formula for fingers: 3 > 4 > 2 > 1.

Hind limbs long (HIL/SVL ratios 1.469-1.872, mean 1.672 ± SE 0.037); tibia long (TBL/SVL ratios 0.515-0.610, mean 0.545 ± SE 0.008); tibiotarsal articulation reaches the nostrils when hind limb is flexed. Heels overlap when hind limbs are held at right angle to the body. Tips of toes dilated into flattened disks that have circummarginal grooves and are smaller than those on the fingers. Broad webbing reaches the base of the disks on all toes, except toe IV, where one phalange is free. A distinct inner metatarsal tubercle is present. Distal subdigital formula for toes: 4 > 5 > 3 > 2 > 1.

Wolffian ducts are convoluted and vescicula seminalis absent in the males.

A 65.2 mm SVL female was partially skeletonized to examine internal features. The skin cover-

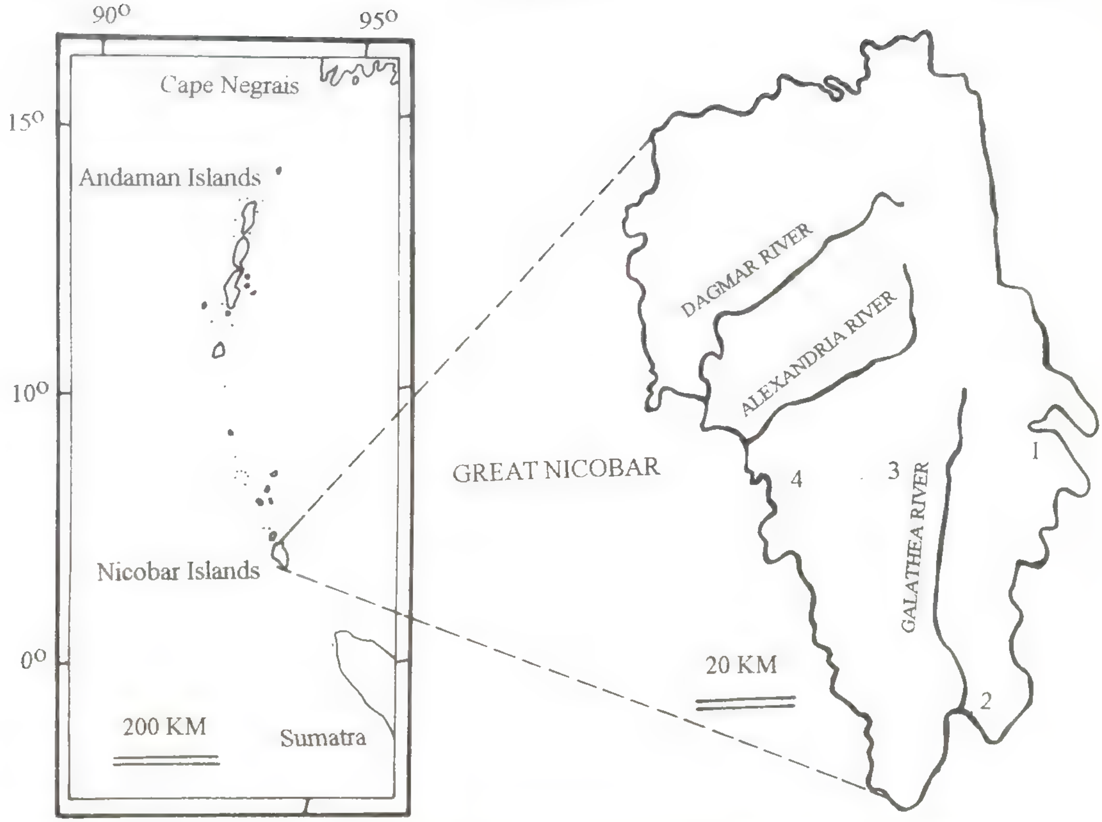


FIGURE 3: The Andaman and Nicobar archipelago (left), showing Great Nicobar (enlarged on right) and the type localities of *Polypedates insularis*. References: 1, Campbell Bay; 2, Galathea National Park; 3, Shompen Hut; 4, Kopen Heat.

ing the cranium is free, not coossified to the frontoparietal, nasal or squamosal bones. Parieto-squamosal arch is short, reaching the occipito-prootic ridge. Pectoral girdle is firmisternal. Anterior end of the frontoparietal is wider than the posterior. The base of the omosternum is slightly forked, the greatest space between the arms less than half the width of one arm (State 1 of Liem, 1970). Metasternum is a narrow bony stylus, its length 48 per cent the total length of the pectoral girdle.

Dorsum with fine scattered granules. Outer edge of the upper eyelid with coarse granules. Throat is smooth. A pebbly finish on the pectoral and abdominal regions, with the presence of fine tubercles. Undersurface of the fore limbs and the top of the undersurface of the thighs are smooth; trailing edge of the undersurface of the hind limbs is with fine rounded tubercles, especially below the vent.

Measurements of the type series are in Tables 1 and 2.

Colour: A dark hour-glass marking is present on the dorsum of seven of the types for which colour notes were taken. The rest were either dark-spotted (two) or unpatterned (two). In life, the dorsum is straw yellow, with a cinnamon saddle. The limbs show cinnamon bands, bands of the same colour, although diffused, evident on the rear of the thighs. The iris is sulfur yellow. Ventrally, cream.

Sexual dimorphism: Females are significantly larger than males, SVL of seven gravid females ranging from 50.8-65.2 (mean 59.343 ± SE 1.940) mm, whereas SVL of four males with enlarged testes were 39.1-43.3 (mean 41.125 ± SE 0.999) mm. Additionally, all four males have nuptial pads on the dorsal surfaces of fingers I and II but no vocal pouches or gular glands (see Liem, 1970) are present.

TABLE 1: Morphometrics of the type series of *Polypedates insularis*. References: SVL, snout-vent length; TBL, tibia length; HW, head width; HL, head length; BW, body width; FL, fore limb length; HIL, hind limb length (in mm.).

Reg. No.	SVL	TBL	HW	HL	BW	FL	HIL	SEX
Holotype								
ZSI A8731	42.2	22.4	13.8	13.4	8.8	25.0	69.4	male
Paratypes								
ZSI A8575	50.8	31.0	19.7	19.2	13.1	26.6	95.1	female
ZSI A8732	63.9	33.3	23.3	19.8	19.7	35.9	101.5	female
ZSI A8733	65.2	33.9	21.7	20.5	20.6	37.8	120.1	female
ZSI A8734	43.3	22.3	14.8	14.7	11.2	24.0	65.8	male
ZSI A8735	57.0	31.8	20.2	19.3	17.8	38.9	94.4	female
ZSI A8736	58.0	31.3	20.7	20.0	20.0	33.3	85.2	female
ZSI A8737	39.1	22.5	13.3	11.6	10.4	19.9	68.7	male
ZSI A8738	63.5	33.8	22.1	20.3	20.2	36.2	107.6	female
ZSI A8739	39.8	22.0	13.4	12.3	8.2	21.2	64.8	male
ZSI A8740	57.0	30.9	20.1	18.8	17.8	25.5	97.8	female

TABLE 2: Morphometrics of the head and phalanges of the type series of *Polypedates insularis*. References: TYD, tympanum diameter; IO, interorbital distance; UE, upper eyelid width; ED, eye diameter; E-N, eye-to-nostril distance; E-S, eye-to-snout distance; F3D, diameter of disk on finger III (in mm.).

Reg. No.	TYD	IO	UE	ED	E-N	E-S	F3D
Holotype							
ZSI A8731	2.8	4.5	4.3	6.0	4.4	6.9	2.1
Paratypes							
ZSI A8575	4.6	7.3	6.0	7.9	7.7	10.6	3.5
ZSI A8732	4.3	7.5	6.8	8.2	7.3	11.0	4.0
ZSI A8733	3.8	8.6	6.9	8.4	7.0	10.8	4.2
ZSI A8734	3.4	5.2	5.0	6.2	5.5	7.8	2.6
ZSI A8735	3.8	5.9	6.0	7.2	6.5	9.9	3.4
ZSI A8736	4.0	7.1	5.8	8.2	6.7	9.9	3.9
ZSI A8737	3.0	5.0	4.2	5.4	4.6	6.7	1.9
ZSI A8738	4.6	7.0	6.4	7.7	7.2	11.2	3.9
ZSI A8739	2.7	5.5	4.1	5.9	4.4	7.0	2.2
ZSI A8740	4.3	6.1	5.8	7.4	6.0	9.7	4.4

Etymology: *insularis* alludes to the insular distribution of the new species.

COMPARISONS

The new species shares several features with *Polypedates maculatus* (Gray, 1834), distributed over the more arid regions of the Indian subcontinent, possessing concave lores, toes 2/3 webbed, head width exceeding head length and in colouration, both species capable of bearing scattered blotches on the dorsum. The Nicobarese species differs from its mainland congener in a number of significant characteristics, such as a relatively small tympanum, which is less than 3/4 the diameter of the eyes (vs tympanum equal to 3/4 eye diameter), narrower disk on the tip of finger III, its diameter less than 1/2 eye diameter (vs equal to half the diameter of the eyes), outer metatarsal tubercle absent (present in *P. maculatus*), finger II larger than finger I (vs both fingers being equal) and is smaller in body size, the SVL of the largest known female of the new species, at 65.2 mm is significantly smaller than that of *P. maculatus*, at 79.0 mm.

Polypedates insularis is compared with congeners from the Indo-Malayan region. It is close to *Polypedates bisacculus* Taylor, 1962 (distribution: Thailand and north-eastern India) in possessing a head that is broader than long, concave lores and absence of the outer metatarsal tubercle, and differs from the aforementioned species in possessing comparatively smaller eyes, eye diameter being less than the eye-nostril distance (vs eye diameter equal to the eye nostril distance), larger body size (female SVL ≤ 65.2 mm, against 29.0 mm), typically an hour-glass pattern on the dorsum (vs a dark unpatterned brown dorsum), toes less than 3/4 (vs 3/4) webbed, absence (vs presence) of tubercles in the undersurface of the arm and relatively long hind limbs, with the tibio-tarsal articulation reaching the nostrils (vs between the eyes and the nostrils).

The new species is also close to *Polypedates colletti* (Boulenger, 1890) in possessing concave lores, eye diameter less than the eye-nostril distance, tympanum diameter less than 3/4 the eye diameter, and an hour-glass shaped mark on the dorsum. However, it can be differentiated from this Indo-Malayan (distribution: Malay Peninsula, Borneo, Sumatra and islands of the South China Sea) by the following features: head broader than long (as opposed to longer than broad), absence of an outer metatarsal tubercle (vs the presence of a small outer metatarsal tubercle) and a significantly smaller body (SVL ≤ 63.5 mm) compared to its more widespread congener (SVL ≤ 75.0 mm).

The new species shares a number of characters with *Polypedates leucomystax* (Gravenhorst, 1829), a widespread south and south-east Asian species (distribution: Sri Lanka, north-eastern India, east to Indo-China, Indo-Malaya, including the Sundas and the Philippines and probably southern China), such as the absence of tubercles on the tarsals and of flaps and dermal fringes along the forearm, the failure of the webbing to reach the distal subarticular tubercle on finger IV, interorbital distance greater than upper eyelid width and the absence of the dark lateral stripe from the eye to beyond axilla. It differs from *P. leucomystax* in having a head that is broader than long (vs longer than broad), concave (not oblique or vertical) lores, eye larger than the eye-nostril diameter (vs eye smaller than the eye-nostril diameter), tympanum diameter less than 3/4 eye diameter (vs 3/4 or greater than eye diameter), toe IV with one (as opposed to two) phalange free of web, no outer metatarsal tubercle (vs a small metatarsal tubercle) and is not known to show stripes on the dorsum, as is the typical condition in its more widespread congener. The skin over the cranium is free in the new species, but is fused to the skull in most specimens of *P. leucomystax* from Borneo that were examined by Matsui *et al.* (1986). Additionally, the new species is smaller in body size, the largest female 63.5 mm in SVL (vs 80.0 mm in *P. leucomystax*).

The Nicobarese species also shows a number of features in common with the widespread *Polypedates eques* Günther, 1858 (distribution: Sri Lanka), such as eye diameter less than the eye-nostril distance, largest disk on finger 3/4 the diameter of the tympanum (which in some examples of the new species is as large as the tympanum), absence of the outer metatarsal tubercle, absence of tubercles on the undersurface of the fore limbs and an hour-glass marking on the dorsum (absent in only a few examples of the new

species). However, the two forms can be differentiated in a number of significant characters, such as head broader than long in *P. insularis* (vs longer than broad in *P. eques*), toes 2/3 (vs 1/2) webbed and the lack of a dermal flap on the hind limbs (present in the widespread congener).

Polypedates insularis shares few significant features with the Sundaic (distribution: Sumatra, Natuna, Borneo, Palawan and the Sulu Archipelago) *Polypedates macrotis* (Boulenger, 1894), including concave lores, and differs in a number of characteristics: head broader than long (vs longer than broad), eye diameter less than the eye-nostril distance (vs eye diameter equal to the eye-nostril distance), tympanum less than 3/4 eye diameter (vs tympanum 3/4 eye diameter), toe IV with one (vs two) phalange free of web and smaller body size (SVL ≤ 63.5 mm, as against ≤ 90.0 mm in its Sundaic congener).

The new species may also be easily differentiated from *Polypedates otilophus* (Boulenger, 1893) from Borneo and Sumatra, with it shares a number of characters, including the absence of the outer metarsal tubercle. Features that differentiate the two taxa include head width (broader than long in the new species, longer than broad in *P. otilophus*), size of eye diameter (less than the eye-nostril distance in *P. insularis*, equal to the eye-nostril distance in *P. otilophus*), extent of webbing on toe IV (one phalange free in the new species, toe half webbed in the Sundaic species) and body size (≤ 63.5 mm in *P. insularis*, ≤ 97.0 mm in *P. otilophus*). Additionally, *P. otilophus* has a remarkable serrated bony crest on the cranium that is absent in the new species.

NATURAL HISTORY NOTES

Microhabitat notes exist for the 10 types that were collected in 1994. At Galathea National Park, three examples were taken from a vegetation-choked puddle, about 30 cm deep, on the side of a forest road, between 2030-2115 hours. The locality was circa 2 km east of the mouth of the Galathea River. These were part of a breeding congregation that also included *Rana chalconota* and *Microhyla heymonsi*. Also recorded at the site was *Bufo melanostictus*. A fourth example of the new species was taken from a shrub, 50 cm above the substrate, at 2205 hours at the same site.

At Shompen Hut, three examples of *Polypedates insularis* were taken along with a new species of *Limnonectes* (of the *Rana macrodon* complex), *Rana chalconota* (a new record for the Nicobars) and *Bufo melanostictus*. Two were found perched on a sapling, approximately 300 and 93 cm above substrate during the day (1300 hours) and at night (2045 hours), respectively, the third from the surface of the road at 2045 hours.

The remaining three examples were taken from the vicinity of Kopen Heat, from a leaf of a sapling, 85 cm above substrate (2000 hours), from the road (2046 hours) and from the leaf of a shrub, 43 cm above substrate (1815 hours). All collection localities were within non-riparian evergreen forests. Amphibians sympatric with the new species being described here include *Bufo melanostictus, Rana chalconota, Rana nicobariensis*, the aforementioned species of *Limnonectes* of the *Rana macrodon* complex and *Microhyla heymonsi*.

All six females dissected contain unpigmented eggs of diameter 1.6-2.5 mm and all four males show enlarged testes. Of the 10 examples (six females; four males) dissected, only one (a male of SVL 39.8 mm) contains food in the stomach (two small cockroaches). The stomachs of three females (SVL 57.0-58.0 mm) contained two to seven large nematodes. The predominance of frogs with empty stomachs suggests cessation of feeding during the breeding season.

At present, the new species is known to be restricted to the island of Great Nicobar, although subsequent surveys in neighbouring islands, especially the virtually unsurveyed Little Nicobar, may reveal the existence of the species. Sarkar (1990) listed *Polypedates leucomystax* as occurring in the Nicobar Islands. A search of the ZSI holdings of the same species with data from the Nicobars indicate the existence of a single example of a *Polypedates* that I have referred to the new species. Thus, based on existing knowledge, the occurrence of *P. leucomystax* from the Nicobars appears to be erroneous. The larval stages of the new species are at present unknown.

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FRESHWATER TURTLES OF DUDHWA NATIONAL PARK AND THEIR CONSERVATION

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(with one text-figure)

ABSTRACT. - This communication deals with the occurrence of freshwater turtles in and around Dudhwa National Park. Sightings during the survey and compilation of all records were maintained from 1991 to 1994. Eight species were recorded, including *Morenia petersi*, which is a new record for the state of Uttar Pradesh and an extention of range of the species by about 440 km. Other notable records for the *terai* region of Uttar Pradesh include *Melanochelys tricarinata* and *M. trijuga*.

KEY WORDS. - Turtles, *terai*, conservation, Dudhwa National Park, India.

INTRODUCTION

In the past few years, focus has shifted from single species conservation to biodiversity conservation. The need to document and inventory other groups apart from the large and threatened species has increased and the current trend is to look at all groups of animals and plants rather than focusing on some particular large, threatened and glamorous species.

The turtle fauna of India comprises 31 species, including 22 freshwater forms (Das, 1985; 1991). Although endemicity in the fauna is significantly high, there have been few studies since the 'Fauna of British India' series on turtles by Smith (1931). Surveys conducted to understand the distribution and status of species have been summarized by Das (1991). There are no published account of studies on the turtles of the north Indian *terai* in general and of the Dudhwa National Park in particular.

Previous studies in Dudhwa National Park have been almost entirely restricted to large species of birds and mammals. Due to the presence of tigers, swamp deer, Bengal florican and rhinoceros, other smaller homoeotherms have received little attention (Javed and Rahmani, 1992). As expected, there is little or no documentation of the reptiles, amphibians and invertebrates. Looking at the paucity of information on the reptile fauna, particularly the turtles, the present survey was undertaken.

STUDY AREA

This study was conducted in and around Dudhwa National Park situated between 28° 18' and 28° 42'N and 80° 28' and 80° 57'E, on the Indo-Nepal border in the Nigahsan Tehsil of Lakhimpur District, Uttar Pradesh. Two rivers, the Suheli and Mohana form part of the natural boundaries of the reserve (Fig. 1). Suheli, a tributary of the Ganga, enters the area from the north-west and flows on an irregular course. The north bank of the Suheli forms the southern boundary of the sal forests, while the Mohana borders it to the north, before it enters Nepal and flows south-east to join the Kaunala.

The 614 sq km area of the Park is largely covered by sal forests, which constitutes about 54 per cent of the total area. The understory consists of *Cleridendrom viscosum*, *Callicarpa macrophylla*, *Glycosymis pentaphylla*, some pteridophytes and *Tiliacora acuminata*, a climber which occurs all over the sal forest and makes a dense cover. The grasslands constitute roughly 23 per cent of the total area, falling under the *Phragmites - Themeda - Imperata* type of Dabadgaho and Shankaranarayan (1973). These subtropical tall grasslands, also known as *terai* grasslands, are characterized by two major types. Upland grass, found at higher elevations, which are characterized by short to medium height (0. 25 - 3 m) grass species like *Imperata cylindrica*, *Saccharum spontaneum*, *S. munj* and

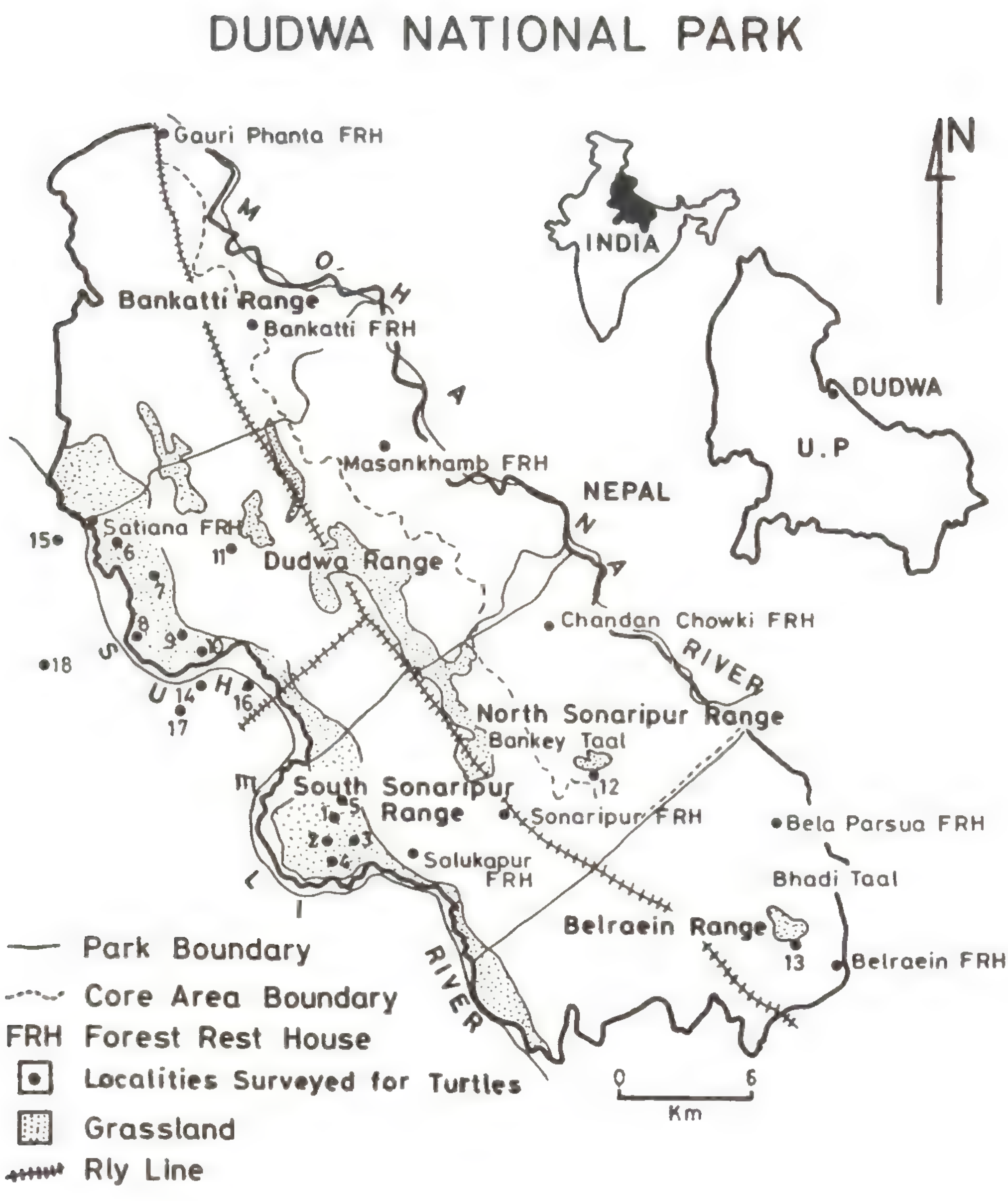

FIGURE 1: Map of study area.

Desmostachya bipinnata as the dominant species. Very tall grasses (3 - 6 m) are found in the low-lying areas or bordering tals, the main species being *Narenga porphyrocoma, Sclerostachya fusca, Arundo donax* and *Phragmites karka*. Miscellaneous forests, plantations and wetlands make up the rest of the area. The presence of two rivers and several standing waterbodies that are locally known as tals, provide habitat for many species of amphibians and reptiles. Most of the tals contain water throughout the year, except for shallow ones like Amaha and Chetwa, which dry up in the month of May for a brief period, before they are either filled by water from the tubewells or from rainfall. Water depth varies from 1-2 m. Monsoon sets in by the first week of June and on average,

the site receives an annual rainfall of 1,300-1,600 mm. Other details of the meteorology of the site has been given by Javed and Rahmani (1992).

MATERIAL AND METHODS

As this study was conducted under the aegis of the Grassland Ecology Project, the scope was limited to surveys. Surveys of waterbodies were conducted between 1991-1993 to document the presence or absence of turtles. Another survey was conducted in the winter of 1994 and all waterbodies were visited. All other casual observations were compiled. As netting permission could not be taken, no netting was done within the Park.

All tals inside the Park were visited fortnightly between December and June each year, while outside the Park, only Ghola tal was visited frequently. The remaining three tals outside the boundary of the Park were visited infrequently, although they were intensively surveyed in April 1993 and later also in 1994.

On an average, one hour was spent at each site, mostly during the mornings. Searches for *Indotestudo elongata* were done in 1992 in Sathiana, Salukapur and Sonaripur sal forests.

RESULTS AND DISCUSSION

In all, 18 sites, 14 within the Park and four outside, were surveyed and the occurrence of turtles documented. Of the localities, 14 were tals, the remaining four grasslands, mostly low-lying and in close proximity to waterbodies (Fig. 1). Eight species of turtles were recorded, the details of which are given below:

Morenia petersi (Indian eyed turtle): This species had been reported from Assam, West Bengal and Bihar (West Champaran District) and was thought to occur in the eastern state of Tripura as well (Das, 1985; 1991). Its known range was extended by about 600 km when it was reported from Bettiah in Bihar by Moll and Vijaya (1986). Frazier (1992) suggested that the species may occur in Uttar Pradesh.

During this study, four sightings were obtained in the south-western side of Dudhwa National Park, from the Sathiana region. In 1992, two indi-

TABLE 1: Presence (+) or absence (-) of turtles at sites in and around Dudhwa National Park.

Sl. No.	Localities	*Kachuga dhongoka*	*Kachuga tecta*	*Hardella thurjii*	*Melanochelys tricarinata*	*Melanochelys trijuga*	*Aspideretes gangeticus*	*Lissemys punctata*	*Morenia petersi*
Within Park									
1.	Kakraha tal	+	+	+	+	-	-	-	-
2.	Chedia tal	+	+	+	+	+	-	-	-
3.	Amaha tal	-	-	-	-	-	-	-	-
4.	Chetwa tal	-	-	-	-	-	-	-	-
5.	Puraina tal	-	-	-	-	+	-	-	-
6.	Sathiana FRH area	-	-	-	+	-	-	-	+
7.	Chapra tal	-	-	+	+	-	-	-	-
8.	Makhan bojhi	-	-	-	-	-	-	-	-
9.	Madrayya	-	-	-	-	-	-	-	-
10.	Mutna tal	-	+	-	-	-	-	-	-
11.	Kawwaghati	-	+	-	-	-	-	-	-
12.	Bankey tal	-	-	-	-	-	-	-	-
13.	Bhadi tal	-	-	-	-	-	-	-	-
14.	Suheli River	-	-	-	-	+	-	-	-
15.	Near Tiger Haven	-	+	-	-	-	+	+	-
Outside Park									
16.	Ghola tal	-	+	+	-	+	-	+	+
17.	Gajrola tal	-	-	-	-	-	-	-	-
18.	Tiger Haven marsh	-	-	-	-	-	-	-	-
19.	Ainthpur marsh	-	-	-	-	-	-	-	-

viduals were seen on April 10 at Chapra tal in Sathiana and were photographed. In 1993, one with an injured carapace was found with a fisherman near Ghola tal (outside the south-western boundary near Sathiana). On both occasions, the identification of the species was confirmed by the presence of longitudinal yellow stripes on the necks and two lines running down from the mandibular region. The carapace was smooth, black and the edges prominently lined with yellow. The black blotches on the scutes were not very conspicuous and only noticeable on close examination.

The occurrence of the species in Dudhwa is the first report of the species from Uttar Pradesh and is the north-western-most limit of its range. This report extends the distribution of the species by about 440 km west of Bettiah, the last-reported site by Moll and Vijaya (1986) and also suggests its occurrence in the Nepal *terai*, as the Sathiana region is a mere three kilometre from the Nepal border. Based on our records from the marsh outside the Park, we believe that the species may also occur in other protected areas within the *terai* and *bhabar* tracts, as well as in marshes and other wetlands outside the protected areas network.

Kachuga dhongoka (Three-striped roofed turtle):Generally found in Kakraha and Chedia tals (Table 1), two individuals were seen and three shells collected from Kakraha tal. The five records are interesting, as these come from tals. Elsewhere, they have been considered to be primarily turtles of flowing waters, and may have reached these tals during floods. Smith (1931) reported the species only as far west as Allahabad on the Ganga, but recent records indicate that it is distributed throughout the drainage of the Ganga, such as sites in Bihar, Madhya Pradesh, Uttar Pradesh and West Bengal, besides Assam, along the Brahmaputra River (Das, 1985; 1991). Moll and Vijaya (1986) have reported the turtle from Nepal and a shell is known from Bangladesh (Khan, 1982).

Kachuga tecta (Indian roofed turtle): One shell was collected from the Katraha tal in 1992. This species was seen once each at Chedia tal, Suheli River, within the Park boundaries and at Ghola tal, outside the south-western boundary of the Park (Table 1).

The species has been reported from Assam, Bihar, Jammu and Kashmir, Madhya Pradesh, Meghalaya, Punjab, Rajasthan, Uttar Pradesh and West Bengal, in addition to adjacent countries such as Nepal, Bangladesh and Pakistan (Das, 1985; 1991). It is thus known with certainty from the Indus, Narmada, Ganga and Brahmaputra river systems (Moll and Vijaya, 1986).

Hardella thurjii (Crowned river turtle): One of the commonest species in the Park, with a total of 14 sightings recorded, mostly in Chapra and Ghola marsh area. A few individuals were also seen in Chedia and Kakraha tals (Table 1). One shell was also collected from near Kakraha tal.

The species occurs in Bihar, Madhya Pradesh, Meghalaya, Punjab, Rajasthan, Uttar Pradesh and West Bengal, in addition to Bangladesh, Nepal and Pakistan (Das, 1985; 1991).

Melanochelys tricarinata (Tricarinate hill turtle): The turtle is also one of the commonly-seen species in the Park. Individuals were often seen in Chapra and Ghola marsh. Shells were also collected. The species was also seen in the low-lying grassland of the Sathiana area. One individual was caught near the Sathiana Rest House, 200 m away from the Suheli River.

The species has been reported from Chota Nagpur and Japaiguri District, North Bengal by Smith (1931). Moll and Vijaya (1986) extended the range to extreme north-western Bihar and suggested the likelihood of its occurrence in adjacent Uttar Pradesh. Dinerstein *et al.* (1987) failed to confirm the presence of the species at the Royal Chitawan National Park in Nepal. The occurrence of the species in Uttar Pradesh was first reported from the *bhabar* tracts of Corbett National Park by Frazier (1992), but its occurrence in the *terai* region is confirmed by our records. As Dudhwa National Park lies on the Nepalese boundary, the close proximity of the site to the Royal Bardia Wildlife Reserve of Nepal suggests that the species may occur in the Nepalese *terai* as well.

Melanochelys trijuga indopeninsularis (Indian black turtle): The turtle occurs commonly in the Park. It was first observed in 1991 near Chedia tal. Individuals of the turtle are fairly commonly-seen in the low-lying areas of the grasslands close to wetlands during the monsoons. Two burnt shells were collected, one each from Chedia and Chapra

grasslands.

This northern subspecies of a widespread turtle has been reported from Singhbhum and West Champaran Districts of Bihar, Jalpaiguri District of West Bengal, as well as western Assam (Das, 1991). Moll and Vijaya (1986) based on their record from Valmiki Nagar, Bihar, close to the Nepal border, suggested the likely occurrence of the turtle in adjacent Uttar Pradesh. Dinerstein *et al.* (1987) reported a turtle of the species from the Royal Chitawan National Park in the Nepalese *terai*. Frazier (1992) found it in Corbett National Park in the *bhabar* tracts of Uttar Pradesh, extending the range by 1,100 km to the north-west. Our records from Dudhwa, the northern-most limit, documents its presence in the Uttar Pradesh *terai*.

Aspideretes gangeticus (Indian softshell turtle): Not commonly-seen, we encountered the turtle on five occasions, as they basked on the bank of the Suheli River near Tiger Haven.

The species is known from Bihar, Madhya Pradesh, Orissa, Punjab, Rajasthan, Uttar Pradesh and West Bengal, in addition to Bangladesh, Nepal and Pakistan (Das, 1985; 1991).

Lissemys punctata (Indian flapshell turtle): Twice seen at Ghola tal outside the Park boundaries and twice in the Suheli River near the Sathiana area of the Park. The sighting at Chapra tal is not certain as it was seen for a very short duration. Das (1991) has reported the spotted subspecies (*andersoni*) from Bihar, Madhya Pradesh, Punjab, Rajasthan, Uttar Pradesh and West Bengal. In Dudhwa, we believe that this species occurs in greater numbers than indicated by our surveys.

OTHER SPECIES

Without netting, a complete inventory of the turtle fauna would be impossible to compile. In the distributional maps of Iverson (1992), species such as *Geoclemys hamiltonii, Kachuga tentoria, K. smithii* and *Aspideretes hurum* have ranges closely approaching the Park. *Indotestudo elongata* is also expected to occur in Dudhwa, since it is known from both Corbett and Rajaji National Parks in Uttar Pradesh (Frazier, 1992). The sal forests, which is associated with the distribution of the species (Das, 1985) comprises about 54 per cent of the total area of Dudhwa National Park.

TURTLE CONSERVATION IN DUDHWA

Of the eight species of turtles that were found in Dudhwa, all are endemic to the Indian region. Of these, four (*Melanochelys tricarinata, Kachuga tecta, Lissemys punctata* and *Aspideretes gangeticus*) are listed in Schedule I of the Indian Wildlife Act of 1972. A recent study of the turtle trade (Choudhury and Bhupathy, 1993) has proposed changes in the existing list of protected species in the Act. The status of *Kachuga dhongoka, Melanochelys trijuga, Morenia petersi* and *Hardella thurjii* are unclear and merit further study. The restricted range of *M. petersi* possibly warrants its inclusion in the Wildlife Act.

Occasional poisoning of the rivers and perennial streams to immobilize by the Tharus, a local tribal community that lives in the buffer zone of the Park and by the Nepalese settlers have caused large-scale mortality in fishes and may have adverse effects on local populations of turtles. The low densities of softshells is thought to be the result of water-poisoning.

The management practice of annual grass-burning does not seem to have any adverse effect of the turtles of the area. The fast-sweeping fires of the grasslands which might cause some mortality of slow-moving reptiles such as pythons and turtles, may not be a major threat, since most turtles are found in the low-lying grasslands or areas close to marshes that are wet and thus saved from the fires. Once in 1992, when a late fire burnt some area of low-lying grasslands in the Sathiana region, two charred *Kachuga tecta* were found. There could have been some mortality in *Melanochelys tricarinata*, as is also frequents grasslands. Vegetation cover for most species inhabiting the tals and their edges is available year round, as the tall grass bordering tals remain green and therefore are not affected by fires. These oases may be only occasionally burnt during late season fires of the summer, a view supported by 10 years of continuous research.

Within the Park, all the tals are protected. Some cases of poaching inside the Park have been reported in the past, but these were mainly for fish and there have been no definite reports of turtles being caught for either local consumption or trade. A few reports of Tharus catching turtles for consumption exist. Fishermen operating in Ghola and

Gajrola tals, adjacent to the Park boundary report the capture of turtles, with species such as *Morenia petersi* being frequently caught for food by communities settled along the south-western boundary of the Park. As water-bodies like Ghola fall beyond the jurisdiction of the National Park, there is no control on the capture of turtles. The Ghola marsh is about a kilometre from the Sathiana Rest House and is an important wetland. The marsh is the rutting ground of the endangered swamp deer (*Cervus duvaucelli duvaucelli*) and is also one of the best areas for another endangered species, the swamp francolin (*Francolinus gularis*). The occurrence of turtle species like *M. petersi* further enhances the value of the wetland for conservation. At present, the area lies under the control of the Revenue Department, but can be taken over by the Forest Department as a satellite core of the Park. The acquisition of the whole stretch between Sathiana and Ghola tal is socio-politically not feasible as there are large settlements in-between. The best way to protect this and similarly important waterbodies in the area is probably to bring them into the protected area network and providing full protection to the area and the species therein. This will enhance conservation and management of key species, such as ungulates, waterbirds and turtles, as well as the overall biodiversity of the highly threatened and fragmented *terai* eco-system.

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AN ILLUSTRATED KEY TO THE TURTLES OF INSULAR SOUTH-EAST ASIA

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(with 10 text-figures)

ABSTRACT. - An illustrated dichotomous key to the 20 species of Testudines that are known from Borneo, Sumatra, Java, Sulawesi, Maluku and the Philippines is provided. The fauna includes members of the families Dermochelyidae (one species), Cheloniidae (three species), Testudinidae (two species), Bataguridae (11 species, including one undescribed) and Trionychidae (three species).

KEYWORDS. - Testudines, illustrated key, Sumatra, Java, Borneo, Sulawesi, Maluku, Philippines.

INTRODUCTION

There have been few studies on the non-marine turtles of insular south-east Asia and the monograph of de Rooij (1915) continues to be the last regional work on the group. The checklist of Iverson (1992) indicates that as many as 18 species of turtles are reliably recorded from the islands, with the record of *Geoemyda spengleri* requiring verification. A checklist and an illustrated dichotomous key to aid identification of field and museum specimens of turtles was prepared, based on data gathered during field work in Brunei Darussalam and Sarawak, coupled with an examination of specimens at the Brunei Museum, Bandar Seri Begawan, Brunei Darussalam; the Sarawak Museum, Kuching, Sarawak, Malaysia; Museum Zoologicum Bogoricum, Bogor, Indonesia; Musée National d'Histoire Naturelle, Paris; Philippines National Museum, Manila; Natural History Museum, London; Oxford University (Zoological Museum), Oxford; Natur-Museum und Forschung-Institut Senckenberg, Frankfurt/Main; Zoologisches Forschunginstitut und Museum Alexander Koenig, Bonn; Naturhistorisches Museum, Vienna; the Natural History Museum, London; and the Zoological Reference Collection, National University of Singapore, Singapore.

The term 'insular south-east Asia' here refers to the Sundaic islands of Borneo, Sumatra, Java, Sulawesi (formerly Celebes), Maluku (formerly Moluccas) and smaller associated islands, as well as the islands of the Philippines. The political units covered include Indonesia, Malaysia (Sarawak and Sabah), Brunei Darussalam and the Republic of the Philippines. The known Testudine fauna of the region belongs exclusively to the Infraorder Cryptodira, as opposed to most of the non-marine Testudines from the islands lying on the Sahul Shelf (New Guinea, Australia and the associated islands) which are members of the Infraorder Pleurodira. This work deals with the turtle fauna of the archipelago west of Webber's Line. The zoogeography of the turtles of the region has been reviewed by Lovich (1994), who predicted the discovery of hitherto undescribed species.

Distributional data are provided for the non-marine species and refer only to distribution in the archipelago, extralimital distribution being omitted. Turtle nomenclature follows Iverson (1992). Additional bibliographic material can be found in David (1994). Nomenclature of shell components are as in Fig. 1. Maximum straight carapace length recorded is provided for each species in the key.

CHECKLIST OF THE TURTLES OF INSULAR SOUTH-EAST ASIA

DERMOCHELYIDAE

1. *Dermochelys coriacea* (Vandelli, 1761). Leatherback sea turtle

CHELONIIDAE

2. *Chelonia mydas* (Linnaeus, 1758), Green turtle

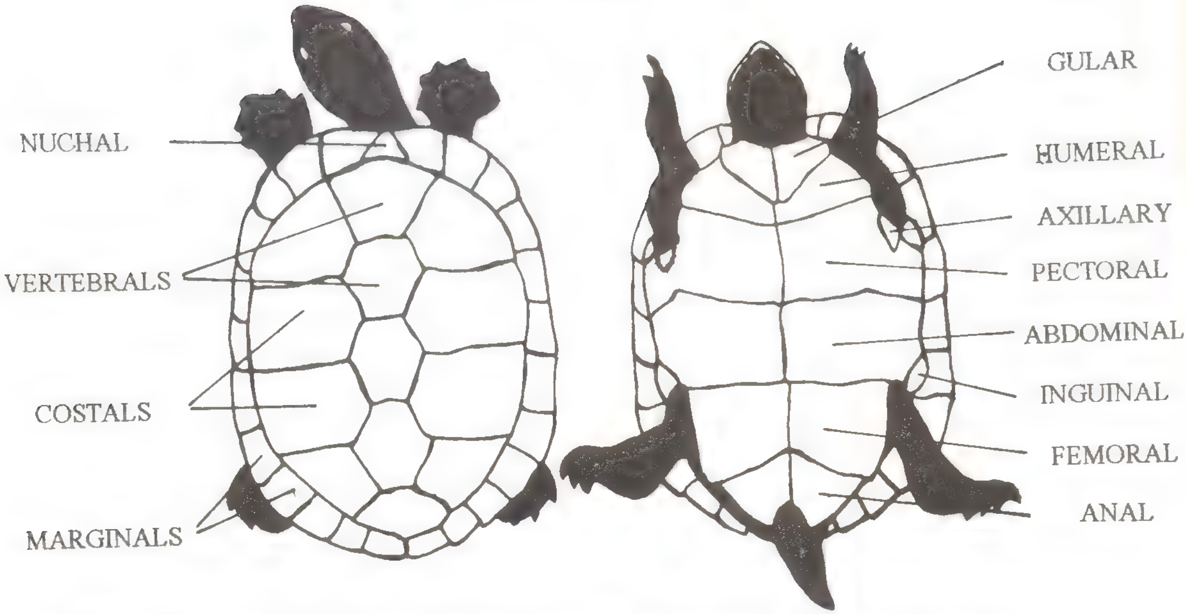


FIGURE 1: Dorsal (left) and ventral (right) views of *Siebenrockiella crassicollis*, showing the carapace and plastron.

3. *Eretmochelys imbricata* (Linnaeus, 1766), Hawksbill sea turtle

4. *Lepidochelys olivacea* (Eschscholtz, 1829), Olive ridley sea turtle

TESTUDINIDAE

5. *Indotestudo forstenii* (Schlegel & Müller, 1844), Travancore tortoise

Distribution: Sulawesi. (likely to be introduced from south-western India; see Groombridge and Wright, 1982.)

6. *Manouria emys* (Schlegel & Müller, 1844), Asian brown tortoise

Distribution: Borneo, Sumatra.

TRIONYCHIDAE

7. *Amyda cartilaginea* (Boddaert, 1770), Malayan softshell turtle

Distribution: Borneo, Java, Sumatra.

8. *Dogania subplana* (Geoffroy-Saint Hillaire, 1809), Asian softshell turtle

Distribution: Borneo, Java, Sumatra.

9. *Pelochelys cantorii* Gray, 1864, Asian giant softshell turtle

Distribution: Borneo, Java, Sumatra, Luzon.

BATAGURIDAE

10. *Batagur baska* (Gray, 1831), River terrapin

Distribution: Sumatra.

11. *Callagur borneoensis* (Schlegel & Müller, 1844), Painted river terrapin

Distribution: Borneo, Sumatra.

12. *Cuora amboinensis* (Daudin, 1801), Malayan box turtle

Distribution: Borneo, Java, Sulawesi, Sumatra, the Philippines archipelago.

13. *Cyclemys dentata* (Gray, 1831), Asian leaf turtle

Distribution: Borneo, Java, Sumatra.

14. *Cyclemys* sp. , Bornean leaf turtle

Distribution: Borneo (Sarawak, north-western Borneo).

15. *Heosemys leytensis* Taylor, 1920: Leyte pond turtle

Distribution: Leyte and Palawan, Philippines

16. *Heosemys spinosa* (Gray, 1831), Spiny turtle

Distribution: Borneo, Sumatra, Mindanao.

17. *Malayemys subtrijuga* (Schlegel & Müller, 1844), Malayan snail-eating turtle

Distribution: Java, Sumatra.

18. *Notochelys platynota* (Gray, 1834), Malayan flat-shelled turtle

Distribution: Borneo, Java, Sumatra.

19. *Orlitia borneensis* Gray, 1873, Malayan giant turtle

Distribution: Borneo, Sumatra.

20. *Siebenrockiella crassicollis* (Gray, 1831). Black marsh turtle

Distribution: Borneo, Java, Sumatra.

ILLUSTRATED KEY TO THE TURTLES OF INSULAR SOUTH-EAST ASIA

1. Fore limbs modified into wing-like flippers. 2

1'. Fore limbs with distinct toes or with webbed feet, never with wing-like flippers 5

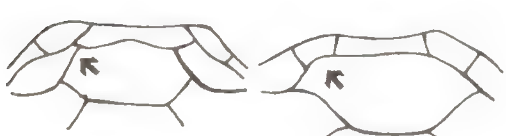
1 1'

2. Carapace with ridges; surface of carapace in adults covered with skin (young with small scales); carapace with seven keels; plastron with five keels; head lacks scalation (maximum length recorded 2. 57 m) . . . . *Dermochelys coriacea*

2'. Carapace lack ridges; surface of carapace covered with scutes; head shows scales 3

3. Six pairs of costals; nuchal in contact with costal I; four enlarged inframarginal scutes in the bridge, each usually with a pore at the posterior border (maximum length recorded 80 cm) . . . . *Lepidochelys olivacea*

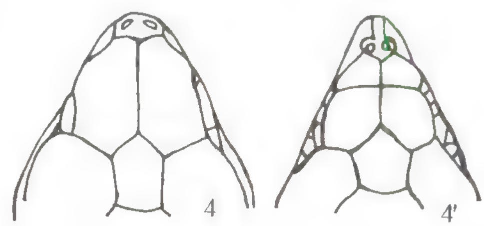
3'. Four pairs of costals; nuchal not in contact with costal I 4



3 3'

4. Scutes on carapace juxtaposed (non-overlapping); posterior margin of carapace slightly serrated; one pair of prefrontals (maximum length recorded 1. 4 m) . . . . *Chelonia mydas*

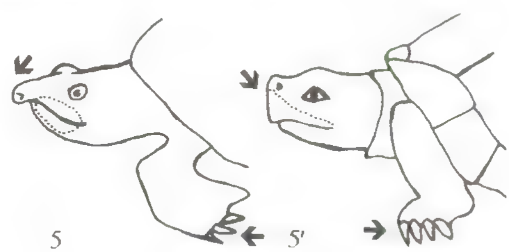
4'. Scutes on carapace imbricate (overlapping) in all except hatchlings and very old turtles; posterior margin of carapace highly serrated; two pairs of prefrontals (maximum length recorded 1. 0 m) . . . . *Eretmochelys imbricata*



4 4'

5. Shell covered with skin; horny mandibles concealed under fleshy lips; three claws . . . 6

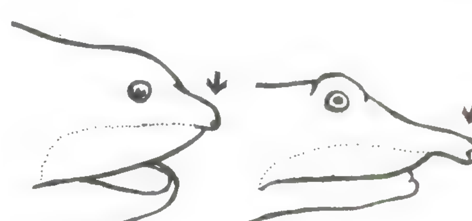
5'. Shell covered with scutes; horny mandibles exposed; four or five claws 8



5 5'

6. Anterior of shell grades smoothly into the skin of the neck; eyes close to the snout; head tiny relative to body; proboscis usually a thin nubbin; carapace flattened (maximum length recorded over 100 cm) . . *Pelochelys cantorii*

6'. Anterior of shell sharply demarcated from the neck; eyes situated laterally; proboscis long. 7



6 6

7. Head large, never spotted with white or yellow; sides of carapace straight; longitudinal row of 20-24 elongated tubercles on carapace; proboscis about as along as eye diameter (maximum length recorded 35 cm) . . . . *Dogania subplana*

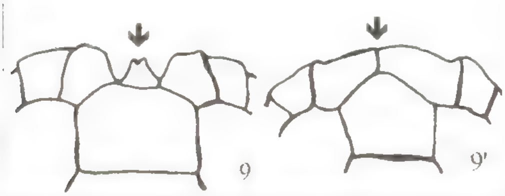
7'. Head small and usually spotted with white or yellow; sides of carapace rounded, without longotudinal rows of tubercles; proboscis longer than eye diameter (maximum length recorded 75 cm) . . . . *Amyda cartilaginea*

8. Large, well-defined scales on snout and between the eyes; two phalanges in each toe . 9

8'. Skin on snout and between the eyes smooth; three phalanges in each toe 10

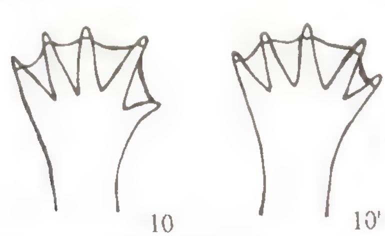
9. Carapace rounded; pectorals separate; nuchal present; marginal XII separate both dorsally and ventrally; conical scales on thighs (maximum length recorded 47 cm) . . . . *Manouria emys*

9'. Carapace elongated; pectorals joined; nuchal present or absent; marginal XII fused; no conical tubercles on thighs (maximum length recorded 33. 1 cm) . . . . *Indotestudo forstenii*



10. Four claws on each fore limb; fingers and toes fully webbed; snout somewhat upturned; nuchal broader than long (maximum length recorded 59 cm) . . . . *Batagur baska*

10'. Five claws on each fore limb 11



11. Plastron joined to carapace by flexible ligament; a hinge, which may be weakly-developed or distinct, is present, at least in adults 12

11'. Plastron sutured solidly to carapace by a bony suture and hinge absent (except in old females of *Heosemys spinosa*) 14

12. Face light-striped; posterior marginals smooth; well-developed plastral hinge between the pectorals and abdominals; plastron rounded posteriorly, yellow with black spots or blotches (maximum lengh recorded 20 cm) . . . . *Cuora amboinensis*

12'. Face unstriped; posterior marginals serrated (except in adults) 13

13. Marginals strongly serrated anteriorly, weakly serrated posteriorly; a strong notch between the gulars and humerals; upper jaw with a distinct hook (maximum length recorded 21 cm) . . . . *Heosemys leytensis*

13'. Marginals weakly serrated anteriorly; strongly serrated posteriorly 14

14. Plastral lobe weakly kinetic in adults . . 15

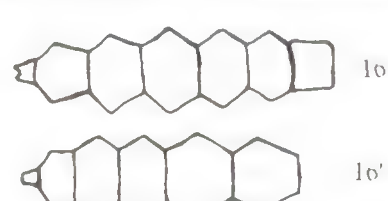
14'. Plastral lobe rigid 16

15. Carapace depressed, with a single median keel, carapace with radiating pattern (maximum length recorded 24 cm) . . . *Cyclemys dentata*

15'. Carapace vaulted; carapace withour radiating pattern (maximum length recorded 18 cm) . . . . *Cyclemys* sp.

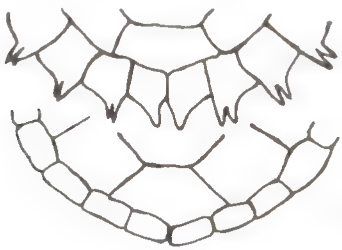
16. Six (rarely seven) vertebrals; a single median keel that is sometimes discontinuous; carapace serrated posteriorly (maximum length recorded 34 cm) . . . . *Notochelys platynota*

16'. Five vertebrals 17



17. Carapace with keels 18
17'. Carapace without keels. 20

18. A single keel on the carapace, situated on the vertebral region; posterior marginals serrated in juveniles but become relatively smooth with growth, upper jaw notched; vertebral II as broad as costal II and broader than long (maximum length recorded 22. 5 cm) . *Heosemys spinosa*
18'. More than one keel on the carapace; posterior marginals smooth 19



18'

19. Forehead covered with skin; head large relative to the body; face and neck striped with yellow; tail withour scales (maximum length recorded 21 cm) . . . . *Malayemys subtrijuga*
19'. Forehead covered with small scales; vertebrals narrower posteriorly than anteriorly (except vertebral V); vertebral II with a hemispherical anterior margin; face unstriped (maximum length 19. 6 cm) . . . . *Siebenrockiella crassicollis*

20. Forehead with scales; five claws on each finger; snout blunt; carapace unpatterned black (maximum length recorded 70 cm) . . . . *Orlitia borneensis*
20'. Forehead without scales; five claws on each finger; snout upturned; carapace grey with three black stripes in adults (maximum length recorded 75 cm) . . . . . *Callagur borneoensis*

Two exotic species of freshwater turtle are now naturalized over much of south-east Asia and are described below:

1. *Trachemys scripta elegans* (Wied, 1839), Red-eared slider Short, blunt snout; with a red or orange stripe behind the eyes; black plastral blotches and transverse bars on the costals. Grows to 35 cm. Originally from the Mississippi Valley, North America. References: Carr (1952); Gibbons (1990).

2. *Pelodiscus sinensis* (Wiegmann, 1835), Chinese softshell turtle. Long snout; the typical subspecies with linearly arranged tubercles on an olive carapace, with or without dark vermiculations. Juveniles with small spots on the carapace and large dark spots on the plastron. Grows to 25 cm. Originally from mainland China, Hainan, Taiwan, Korea, northern Vietnam and Japan. References: Bourret and Le Poulain (1941); Gu and Zhang (1990).

ACKNOWLEDGEMENTS

Supported by research grant UBD/T6/RG 03 from Universiti Brunei Darussalam, British Council Division and Station d'Observation de Protection des Tortues des Maures. I thank Marina Wong (Brunei Museum), Charles Leh (Sarawak Museum), Alain Dubois and Ivan Ineich (Musée National d'Histoire Naturelle), Rogelio Sison (Philippines National Museum), Colin J. McCarthy (Natural History Museum, London) and Chan Man Wang and Kelvin K. P. Lim (Zoological Reference Collection) for various courtesies and to David S. Edwards, Satish Choy, Albert G. Orr, Helen Pang, Kamariah Abu Salim and Webber Booth for support and numerous favours; Joseph K. Charles, David T. Jones and Samhan bin Nyawah, for assistance and company during field work and Peter C. H. Pritchard, John B. Iverson and Peter Paul van Dijk for reading an earlier draft of the manuscript.

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NOTES

Hamadryad, Vol. 20, pp. 33-34, 1995

NOTES ON GROWTH AND MATURITY IN THE INDIAN SOFTSHELL TURTLE (*ASPIDERETES GANGETICUS*)

(with one text-figure)

Sayaji Baug Zoo, Vadodara, Gujarat, India, has been successfully breeding the Indian softshell turtle (*Aspideretes gangeticus*) since 1990. The first batch of seven hatchlings were maintained for studies on growth and maturity.

The hatchlings were kept in a round enclosure of area 28. 28 sq m, including a 4. 0 sq m irregular body of water, 0. 5 m deep, which is accessible by two concrete ramps. The enclosure was landscaped with stones and a few *Cyperus* bushes.

They were daily fed 50-60 live guppy fish (*Poecilia reticulata*) and tadpoles (of *Euphlyctis cyanophlyctis* and *Hoplobatrachus tigerinus*) during the first three months, and thereafter on chopped tilapia fish (*Oreochromis mossambica*), of which approximately 50, 75 and 80 gm were offered daily during the first, second and third years, respectively. Once a week, the hatchlings were given the leaves of coriander and *Hydrilla* sp. Antagonistic behaviour was noticed within the siblings, and two were lost after the first year to cannibalism.

All seven hatchlings were flat and had oval bodies of olive-green colour, with three to six eye-like markings on the carapace and three to five black lines on the forehead. After three years, all eye-like markings faded from the carapace, but the head markings persisted. Sexually-dimorphic features, such as elongated tails in the males, were not seen on any of the three year old turtles.

According to Daniel (1983), young turtles grow rapidly. Measurements of the hatchlings (Fig. 1) show that the mean increase in body size was x 52 after three years. A small *Aspideretes gangeticus* (curved carapace length 35 cm; curved carapace width 30 cm) was caught from Raja-Rani Talao, Vadodara, Gujarat State, on August 1, 1988 (Vyas, 1989). Based on the growth data in Table 1, it was assumed that the turtle was five to six years old at the time of capture (although as a cautionary note, it must be mentioned that growth in captivity can be quite different from that attained by wild turtles). The same turtle produced 22 eggs four years later, on October 15, 1992, at straight carapace length 40. 0 cm, suggesting that the female of the species may attain maturity in nine to 10 years.

I thank V. A. Jadeja, Curator of the Sayaji Baug Zoo, Vadodara, for the support and facilities extended and to Peter Paul van Dijk and an anonymous reviewer for comments on the manuscript.

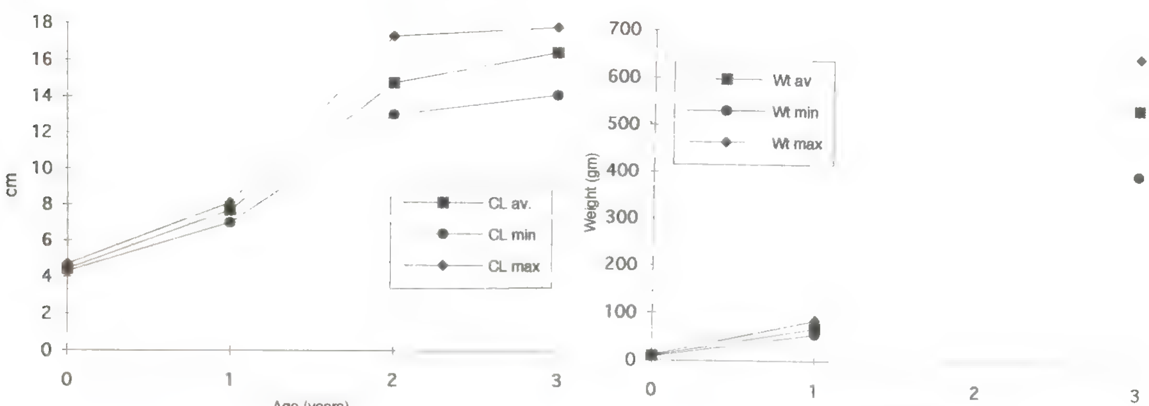

FIGURE 1: Log-scale growth (left, carapace length; right, body weight) in the Indian softshell turtles (*Aspideretes gangeticus*) at Sayaji Baug Zoo, Vadodara, Gujarat, India.

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Raju Vyas, Sayaji Baug Zoo, Vadodara 390 018, Gujarat, India.

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OBSERVATIONS ON GROWTH IN THE INDIAN ROCK PYTHON (*PYTHON MOLURUS MOLURUS*) IN CAPTIVITY

(with one text-figure)

The Indian rock python (*Python molurus molurus*) has successfully bred at the Sayaji Baug Zoo, Vadodara, Gujarat, western India, since 1991. The adult female measured 2. 67 m (total body length) and weighed 12. 5 kg in March, 1991. It is not known whether she had produced eggs before, and the first batch of 15 eggs laid in the

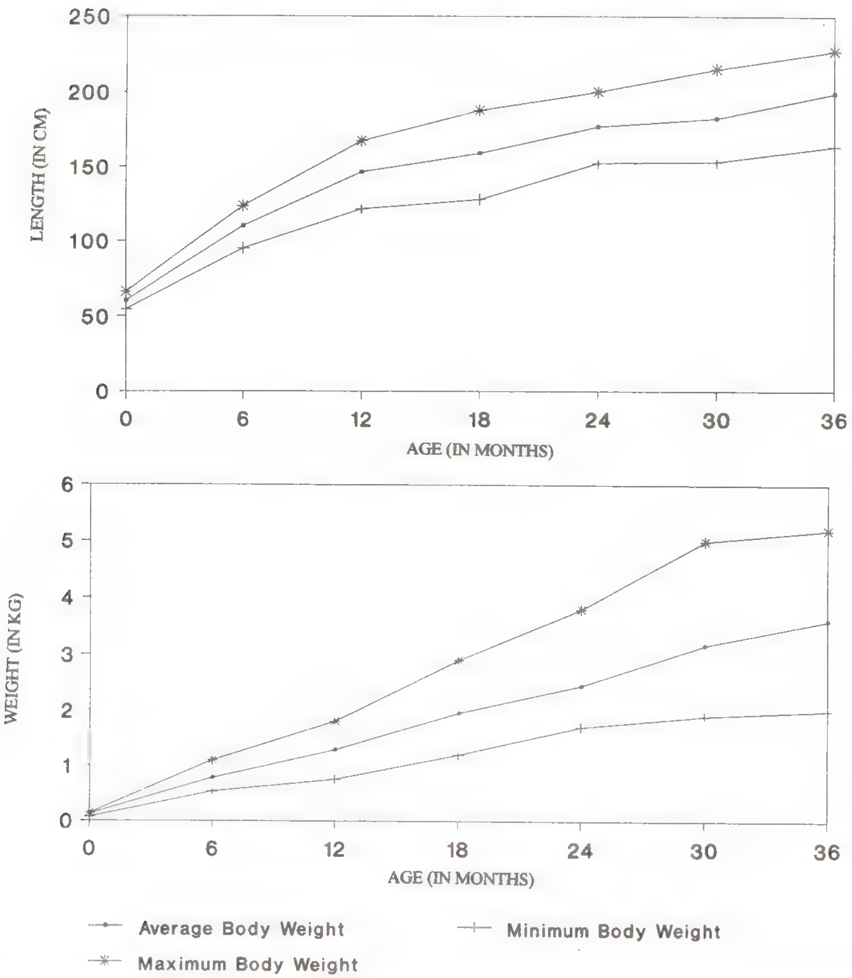

FIGURE 1 : Half-yearly growth in length (top) and body weight (bottom) in the Indian rock python (*Python molurus molurus*) from hatching till three years at Sayaji Baug Zoo, Vadodara, Gujarat, India.

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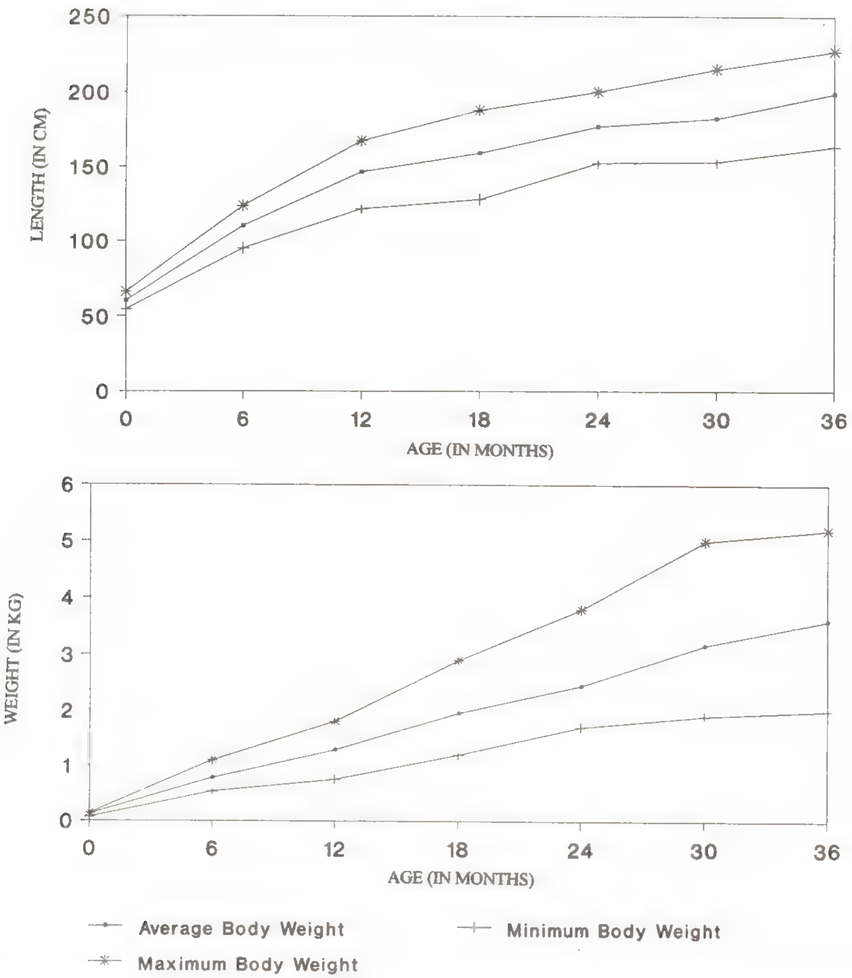

FIGURE 1 : Half-yearly growth in length (top) and body weight (bottom) in the Indian rock python (*Python molurus molurus*) from hatching till three years at Sayaji Baug Zoo, Vadodara, Gujarat, India.

zoo produced seven hatchlings, whose growth was monitored in 75 x 55 x 65 cm glass-fronted wooden cages. Each individual was maintained separately.

Data, including total body length, TBL, and body weight, WT, measured every six months, were taken for three years (Figs. 1 and 2). Hatchlings measured 60. 1 (mean 54. 5-66. 0) cm. They were fed small mice during the first three months, and on rats subsequently in the first year. Pigeons were fed in the second year. After two years, the young pythons accepted small chickens. Food was offered at intervals of four to six days, the interval being up to 15-20 days during the cooler months.

Mean annual growth was 86. 56 cm (TBL) and 1,156. 2 gm (WT) in the first year and 30. 54 cm and 1,166. 7 gm, in the second year. Growth in the third year was 22. 3 cm and 1,150. 0 gm.

Comparisons show faster growth in the present sample (11. 86 cm/year and 303. 58 gm/year) than in other published reports (e. g., Acharjyo and Mishra, 1980; Rathinasabapathy and Kalaiarasan, 1993). However, growth was slower than reported by Acharjyo and Mishra (1980) in the second and third years. Growth of female pythons was more rapid than that of males, mean female TBL 210. 75 cm and BW 4,200 gm (n = 4), while males averaged 176. 25 cm and 2,400 gm (n = 2).

I thank V. A. Jadeja, Curator, Sayaji Baug Zoo, for the support and facilities and Roger Avery for his comments on the manuscript.

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Accepted: September 3, 1995.

BOOK REVIEWS

SEA SNAKE TOXINOLOGY Edited by P. Gopalakrishnakone. 1994. Singapore University Press, National University of Singapore, Singapore. 251 pp. Available from: Singapore University Press, Kent Ridge, Singapore 0511. Price not mentioned.

Dr. P. Gopalakrishnakone has done it again! In 1987, he and L. K. Tan edited the volume "Progress in venom and toxin research" and in 1990, he and L. M. Chou came out with "Snakes of medical importance: Asia and Pacific region". These and the present volume "Sea snake toxinology" are concerned with the Asia-Pacific region and the Venom and Toxin Research Group of the National University of Singapore deserves credit for publishing these well-produced, somewhat austere books. Colour reproduction is very good and the only comment here is that preserved specimens should not be used as supposed aids for identification of the species- they are often unrecognizable.

The first chapter is 'Sea snake bites in the Asia-Pacific Region'. David Warrell, with credentials as one of the authorities on snake-bite in our region, has done a lot with a relative paucity of data or case histories. Drawing heavily from H. A. Reid's pioneering work on sea snake bite in Malaysia to summarize what is known, Warrell then brings us up to date on the pathology and treatment of sea snake bites. Table 2 tells us that *Enhydrina schistosa* is perhaps the cause of most deaths- it certainly is one of the most frequently-seen species in nets along India's coastline. Death from sea snake bite may take 2. 5 hours to 23 days, with an average of about 15-20 hours. But there are insufficient data to know the percentage of bites that proves fatal.

Chapter Two, 'The venom apparatus of sea snakes' is by Drs. Gopalakrishnakone, Miriam Wolberg and Elazan Kochva, the latter two scientists from the Tel Aviv University. This profusely illustrated technical chapter is an overview of what is known about sea snake venom apparatus and the pictures include electron micrographs of fangs, head muscles of sea snakes, sections of muscle tissue surrounding the venom glands, sections of main and accessory venom glands of several species. A venom yield table shows that sea snakes don't yield large quantities of venom but *E. schistosa* heads the list with an output of 80 mg (dry weight).

Chapter Three is on the molecular biology of sea snake toxins, in which Evelyne Lajeunesse and seven of her colleagues investigate and describe the cloning of DNAs and genes that encode sea snake toxins. They conclude that their present work (including the productions of recombinant toxins) can lead to: *a.* labelling of toxins with isotopes to study toxin structure associated with antibodies, *b.* transformation of a toxin function into another, and *c.* creation of new toxin functions. These cloning experiments have revealed the presence of undiscovered toxins, indicating that sea snake toxinology is as yet a young field.

Chapter Four, 'A review of contemporary sea snake toxinology' by George V. Pickwell, takes up over a quarter of the volume and well it should. With its concise but apparently complete summaries of what we know of sea snake toxinology, supported by an extensive 20 page bibliography, this chapter is a self-contained 'handbook' on the subject. Anyone who wishes to see where we stand with reference to studies on sea snake bite and venom research needs to read this chapter.

Chapter Five is 'Sea snakes of Australia' by Harold Heatwole and Harold Cogger. Excellent colour photographs and illustrated key and detailed species descriptions make this chapter a bit of a field guide. This is combined with information on venoms, threats to humans, treatment of bites and finally, sea snakes in Australian culture and commerce.

Chapters Six, Seven and Eight are short accounts of sea snakes of Japan (by M. Toriba), Fiji (by Michael L. Guinea) and Sri Lanka (by Anslem De Silva). These accounts rehash species descriptions to some extent, but give useful information on bites, toxicity and a bit about behaviour (*Laticauda*'s notable reluctance to bite, for instance). Only one obvious error was noted: in Guinea's remarks on the distribution of *Laticauda colubrina*, he says that the species is

not common in Indo-Burmese waters. We find, however, in our field work in the Andaman and Nicobar Islands that this is a common species indeed in this archipelago of over 300 islands.

In general, this is an excellent collection of current data on sea snake toxinology. It is regrettable that there are no contributors from India (with 10,000 kilometres of sea snake-rich coastline).

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THE BENGAL MONITOR by Walter Auffenberg. 1994. University Press of Florida, Gainesville. 588 pp. Available from University Press of Florida, 15 NW 15th Street, Gainesville, Florida 32611, USA. Price: £ 72. 00.

"The Bengal monitor" completes Dr. Walter Auffenberg's monumental trilogy of Asia's three large monitor species, the other two being the Komodo dragon, *Varanus komodoensis* (Auffenberg, 1981) and Gray's monitor, *V. olivaceus* (Auffenberg, 1988). Each is a scholarly work and this, doubtless the finest and a lasting contribution by a distinguished scholar to tropical ecology and conservation biology. Autecological studies, unfortunately, comprises neither the cutting edge of research nor receive the publicity now hogged by the (usually political) studies of biodiversity. Nonetheless, the heart of biodiversity being the species themselves, few will deny the importance of gathering as much natural history data on tropical species, to answer questions in evolutionary biology, to understand the conservation requirements, particularly in the case of large, distinctive and commercially valuable taxa or even for its own sake.

This book is concerned with the biology of the Bengal or land monitor, *Varanus bengalensis*, which for a long time was referred to as *Varanus monitor* in the early literature, till Sprackland (1982) showed that the older name was valid for the taxon. Our species enjoys perhaps the widest distribution among all living species of monitors: from Afghanistan and extreme eastern Iran eastwards to India (the typical subspecies), east through Indo-China, Sumatra and Java (the subspecies *nebulosus;* considered by Böhme, 1988, to warrant the status of a full species). In a map of the range of *Varanus bengalensis* sensu lato (Fig. 1-1, page 2), the author shows the total time spent in the field at each site, with study sites spanning nearly the entire range of the species (excluding of course, strife-torn Iran, Afghanistan and Indo-China).

Walter Auffenberg is Distinguished Research Curator Emeritus at the Florida Museum of Natural History (formerly, Florida State Museum), at Gainesville, Florida, USA. A tireless field worker, Auffenberg has both collected and reported on the natural history of many tropical Asian reptiles, including his own speciality: the giant monitor lizards, in addition to his classical studies of fossil tortoises and snakes. As the tail-piece of the book being reviewed says, besides his field work, Auffenberg also made observations on the behaviour of monitors that he brought back to his Gainesville home.

The section on study areas reflects the elaborate work done in sampling the vegetation at the study sites and the determination of prey densities. We learn here that Auffenberg and party put transmitters with reliable signal recovery distance of about half a kilometre on monitors to study home ranges and activity patterns. 153 pleasing line drawings, that includes the animals, their habitats and maps, have been executed by the author himself, who is a gifted scientific illustrator.

Appendices cover local names used for the species, references to physiological processes and morphometry, abbreviations used, myths and beliefs concerning the species, and a supplementary bibliography of the plants and animals mentioned in the text that occur in Bengal monitor habitats. The Literature Cited section is 50 pages long and lists virtually everything worthwhile ever published on these giant lizards (it certainly covers everything I have seen onthe Bengal monitor).

In a three page epilogue, Auffenberg summarizes the various threats to his study species and concludes that the ultimate solution for all re-

source conservation needs, is not controlling deforestation, but our own growth rate.

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Indraneil Das, Centre for Herpetology, Madras Crocodile Bank Trust, Post Bag 4, Mamallapuram, Tamil Nadu 603 104, India.

ANURAN (AMPHIBIAN) FAUNA OF NORTHEAST INDIA by S. K. Chanda 1994. *Memoirs of the Zoological Survey of India* Vol. 18., No. 2: 1-143 + maps. Available from Zoological Survey of India, Publications Department, Nizam Palace, Calcutta 700 016, India. Price: Rupees 185, US$ 15. 00 or £ 10. 00.

This description of the toads and frogs of north-east India by Dr. S. K. Chanda of the Zoological Survey of India is a significant and timely piece of work. Till now, herpetologists in India have been relying on the over one hundred year old work of Boulenger (1890) and publications scattered in various technical publications and this illustrated update gives us access to the anurans of the biologically rich north-east.

The monograph begins with a short description of the geography, climate and vegetation of the seven states of north-eastern India (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura). It is a region of river valleys and flood plains with tropical vegetation at elevations as low as 500 m. It also encompasses temperate forests at middle elevations up to alpine regions of over 5,500 m. The collections were done in the hill ranges that have always seemed magical to herpetologists: the Mikirs, Garos, Khasis and Nagas- all also names of the strong-willed tribal people of these hills. Here, rainfall averages over 250 cm per year and include the world's highest rainfall at Mawsynram, in the Khasi hills, about 20 km from Cherrapunji.

Chanda records 54 species of frogs and toads of 18 genera and six families and then proceeds to summarize anuran morphology and the terminology of toad and frog taxonomy. This is useful as the reader goes through the keys and genera and then individual species descriptions. The descriptions are clear and concise in most cases but the text could have benefitted by being carefully proof-read and edited for grammar. Under 'Remarks' we occasionally learn some interesting and significant facts about the species or its habitat. For example, in the description of a frog recently described by the author (*Rana ghoshi*), he says this under 'Remarks': "It is found to occur in the overhanging vegetation near the (sic) stream, and is diurnal species" and for *Pterorana khare*: "It is nocturnal, found in swift waterfalls among rocks Sometimes it glides for a considerable distance and may be called as (sic) 'gliding frog'". But there are not nearly enough of these descriptions of the microhabitat or what the frog is like in life. One of the highlights of the book are the simple and well rendered line drawings by ZSI artist, S. S. Roy.

Scientific names should be italicized, or at least, underlined in any technical publication "Diagnosis" is generally a subheading under which the descriptive details of head, fore limbs and hind limbs naturally fall. In this treatment, each of these features is given subheading status equal to "Diagnosis". Some references given in the text are not listed in the bibliography. In several species, the author was unable to examine any specimens. In 12 species, only one specimen was available and in half of the 54 species, five or less specimens have been seen by the author which highlights the scarcity of material from the region in collections.

Table 1 is a good summary of numbers of families, genera and species of anurans in the world compared to India's and north-east India's. Table II compares the anurans of north-east India

to south and north India and Myanmar (formerly Burma). From this, it is interesting to note that no less than eight species are also common to south. India, several with discontinuous distribution. An adequate bibliography (apart from the omissions referred to) is followed by 21 very simply drawn maps of north-eastern India. These would have been valuable if precise indications of collection of localities were provided on relief maps, instead of mere indications of the states where each species occurs on maps showing the political boundaries.

We all know that much of the wild country in the north-east has historically been cleared for huge plantations and for *jhumming* (shifting cultivation). Today, greed for timber and daily needs for fire wood are finishing off what is left at an alarming rate. Amphibians, being so dependent on temperature and humidity, are clearly some of the first taxa to suffer from rapid human development Dr. Chanda does put a paragraph in his introduction which refers to amphibian usefulness and the need for conservation. It would be even more helpful if biologists were to emphasize the rapid declines of amphibian populations from habitat loss and the host of other reasons possibly linked to global warming, acid rain and other man-created processes. People will listen to specialists and scientific statements can lend weight to control of ill-advised development.

This work will serve as our field guide to the anuran amphibians of north-eastern India and there is no doubt that it will encourage further amphibian researchers in a region that still holds many unknown species.

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BOULENGER, G. A. 1890 The fauna of British India. Reptilia and Batrachia. Taylor and Francis, London.

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MURTHY, T. S. N. 1995. Illustrated encyclopaedia of the reptiles of India. B. R. Publishing Corporation, Delhi. 113 pp. Available from B. R. Publishing Corporation, Delhi 110 052, India. Price Rupees 2,400.

A book weighing 2.4 kilos and of dimensions 17.5"x 11.5" was bought for our library here at the Centre for Herpetology. I took this awesome-sized book with a very comprehensive title to find out what went into it. I began with the inside cover of the front jacket . The author's contention of the book being, "... offered in fulfilment of the long felt comprehensive book on the reptiles of India with each and every reptile found in India, be it on land or on (sic) water", increased my curiosity and made me go through the rest of the book. Towards the end I was not sure whether my knowledge of Indian reptiles was enhanced.

The book has been organized into five chapters, besides Acknowledgements, Foreword (by A. G. K. Menon), Preface and Appendices A-D. The author starts with the statement in the preface, "... no single book .... describes the few dangerous crocodiles and several venomous land and sea snakes". The author seems to be unaware of the work by Daniels (1983) which is till date the only well written book on Indian reptiles. A similar statement is made in the Foreword by A. G. K. Menon of the non-availability of books on popular herpetology.

The book is divided into Dangerous reptiles of India (Chapter 1) and Some common and unusual, harmless reptiles of India (Chapter 2). The remaining three chapters are Snake bites in India and treatment, Snakes in facts and fiction and Men versus reptiles, respectively. Chapters 1 and 2 form an amazing comedy of errors which probably has no precedent in the history of herpetology. More species have been misidentified than can be considered acceptable and in some cases, the same photograph has been identified as of different species. No credit is given to photographers either on the pages the photos appear or in a special acknowledgement section. The book has many unaccountable typographical errors. Species names have either been wrongly spelt (e.g., *Cerberus rynchops*), or international nomencla-

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ture of describing the first letter of species name in lower case (e.g., *Typhlops Porrectus*, *Ramphotyphlops Braminus*) violated. In Chapter 1, that is spread across two pages (18 and 19) is the picture of *Crocodylus palustris* misidentified as *C. porosus* (Fig. 1). The same photograph has been identified as *C. palustris* on page 20 (Fig. 2). The author mentions eight species of kraits found in India. There are only six species of kraits (genus *Bungarus*) found within the political boundaries of India and two occur extralimitally, in Sri Lanka (Das, 1994). After the revision in the systematics of the Asiatic cobras (Wüster and Thorpe, 1992), many taxa that were considered subspecies have been elevated to the rank of species. Thus the Indian cobras are now *Naja naja*, *N. kaouthia* and *N. oxiana*. Fig. 12, however dramatic is not enough to identify an acellate cobra, *N. oxiana*. The presence of a small cuneate scale between the edge of the mouth and the 3rd and 4th infralabials (see Wüster and Thorpe, 1992) distinguishes this cobra from the other two Indian cobras. Fig. 23 is not a levantine viper (*Vipera lebetina*) but a colour morph of the Russell's viper (*V. russelii*). The north Indian Russell's viper tends to be darker with solid spots compared to the south Indian ones (Whitaker, 1978). The levantine viper has no spots on the head, which start only from the neck (see Latiffi, 1985). The illustrations of *Trimeresurus macrolepis* is the same as that of *Agkistrodon himalayanus* (Fig. 25 and 26, pg 42 and 43). It is a challenge for the readers to find out which of the species have been accurately identified. Fig. 25 and 26 are those of *A. himalayanus*.

This trend of mistakes are followed even through Chapter 2. On page 53, *Eretmochelys imbricata* has been identified as *Chelonia mydas*. Fig. 33 seems to be that of hawksbill turtle. *Caretta caretta* (Fig. 36, page 55) has been identified as *Dermochelys coriacea*. The easily observable and identifiable freshwater turtle species have not been spared. *Kachuga tentoria* is identified as *K. tecta* (Fig. 38, page 56). Schoepff would probably turn in his grave to see his name spelt as Schoepitt (pg 57). The Indian flapshell turtle, *Lissemys punctata* has been placed in the family Emydidae instead of Trionychidae. There are seven species of Trionychidae (Das, 1994) as against six species mentioned by the author. Fig. 42 is for sleuths to figure out: is it a *Trionyx* (now *Aspideretes*) *gangeticus* or *T.* (now *Aspideretes*) *hurum* (it is actually *Aspideretes leithii*)? Moving towards our more creepy crawlies, Murthy states that the Tokay gecko, *Gekko gecko* (generic name misspelt) is the largest living gecko. The New Caledonian giant gecko, *Hoplodactylus delacourti* that attains a body size of up to 600 mm takes that honour. *Eublepharis macularius* is generally called the leopard gecko or fat-tailed gecko, not spotted cat-eyed gecko. Even a preserved specimen can make a fairly good identifiable picture if photographed carefully instead of putting it on a garden plant. Fig. 49 (top) of flying lizard is one such case. There is no description given for *Calotes rouxii*, Fig. 54. *Lygosoma* sp. (Fig. 59, top) has been identified as *Mabuya carinata*, *Varanus salvator* as *V. flavescens* and vice versa in Fig. 64 and 65 (pages 75 and 76). *Typhlops porrectus* shown in Fig. 66 looks more like a black line. Identification of shieldtailed snakes is difficult and Figs. 67 and 68 are not helpful. Fig. 89 is that of *Cantoria violacea* and not *Cerberus rynchops*. The snake illustrated as *Psammodynastes pulverulenta* (Fig. 90) is not a member of that genus.

Chapter 3 gives useful information on snake bite and treatment and also few lines on antivenom which the author rightly mentions as the only effective cure for snake bites. Chapter 4 is helpful in dispelling erroneous notions people have about snakes. The whole chapter makes interesting reading. In the last chapter the author talks about our interaction with reptiles and their commercial value. In the paragraph on 'Snakes are the real rat killers', the author tells us about the importance of snakes. He also makes an appeal in the last paragraph to conserve our reptilian fauna.

Scientific names and distribution of the dangerous and venomous reptiles are given with their taxonomic details in Appendix A on pages 104 and 105. Vernacular names form Appendix B (pages 106 to 109) and can be useful in the field. In Appendix C on suggested reading, Murthy has missed out many important books written on Indian reptiles (Das, 1991; Dash and Kar, 1990; Mahendra, 1984; Pritchard, 1979). Appendix D, the glossary includes commonly used words like adult, anterior, biota, environment, specks, spots

which do not need explanation while some words like inguinal, juxtaposed and niche that need explanation are inadequately explained. The index is unpaginated, and therefore serves no purpose.

Only 90 species of reptiles (less than a fifth of our fauna, with 632 species) have been dealt with in the volume under review, and of these, only 75 have been illustrated. The title of the book is therefore a bit pretentious. The printing is sloppy with different font sizes. Through prudent selection of photographs and proper layout, the size of the book (and hopefully the price) could have been greatly reduced. This book is too confusing to be recommended to amateurs who want to learn about reptiles, leave alone serious herpetologists. The reptiles of India still need a good comprehensive book.

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AMPHIBIANS OF WEST BENGAL PLAINS by Kaushik Deuti and B. C. Bharati Goswami. 1995. World Wide Fund for Nature- India (Eastern Region), Calcutta. 53 pp. Available from: World Wide Fund for Nature- India (Eastern Region), Tata Centre, 43 Chowringhee Road, Calcutta 700 016, India. Price: Rupees 100.

Whenever a publication appears about Indian herps, we all sit up and take notice. Good ones are few and far between. Amphibians have been especially neglected and it was a pleasure to receive a copy of Deuti and Goswami's small book "Amphibians of West Bengal plains".

Written in a simple style, the layman is only occasionally intimidated by phrases like "amplexus is axillary" or "microphagous tadpoles". The book begins with a word on amphibians in general and a brief description of West Bengal. This is indeed a region of great geographic diversity- extending from Himalayan peaks to the mighty mangrove delta called the Sunderbans and predictably, its biodiversity is impressive. The plains of West Bengal have to a great extent long been deforested and converted to agriculture and not as rich as the hilly areas. The authors describe the 15 species of toads and frogs that they have recorded from the plains and provide a colour plate of each one. With the exception of *Microhyla ornata*, the colour plates are good enough to aid in field identification. For the more exacting naturalist, keys and descriptions of how to identify toads and frogs by physical characters are given. The main diagnostic features are italicized in the text, a useful device for quick reference. The text is concise and well written. Toads, however, are described as poor swimmers which "do breast strokes". Actually, they fold their front legs to the side like frogs and swim quite effectively by kicking their hind webbed feet (though not nearly as powerfully as do some of the ranid frogs).

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frogs, their distribution in the Andaman Islands should have been mentioned. Another criticism is about the common names. Looking at English names already given to frogs in the literature, it is seen that the skipping frog of the authors has been previously called skittering frog; ornate microhylid called ornate narrow-mouthed frog; and cricket frog called paddy frog. This seems a minor issue, but consistency in common names is very helpful to the non-specialist for whom the book is intended.

The book finishes with a brief note about the importance of amphibians and their conservation. In my opinion, more could have been said about the international concern for the disappearance of amphibian populations worldwide. This phenomenon is the focus of an IUCN specialist network called "Declining Amphibian Task Force". It is thought by experts that there may be a far-reaching significance to amphibian die-offs and they propose these sensitive-skinned creatures as bio-indicators on a rapidly changing planet.

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ANNOUNCEMENTS

THIRD WORLD CONGRESS OF HERPETOLOGY
(including 9th Ordinary Business Meeting of the Societias Europaea Herpetologica)
Prague, Czech Republic, 2-10 August 1997

Prague was proposed as a venue for the 3rd World Congress of Herpetology for reasons that are partly practical, e.g., low costs for a high standard convention facilities, easy accessibility. The Congress will feature both scientific and social events. There will be evening programmes, selected in a way that will encourage people to establish personal contacts. The plenary lectures, together with the opening and closing ceremonies, will be held in the Congress Hall, which has a capacity of 1850 seats. Ten concurrent scientific sessions will run in halls with capacities of 50-200 seats. Parallel projection on two screen, overhead projectors, videos, 400 panels for poster exhibitions, rehearsal rooms for meetings of committees and special interest groups will be available. The Academy of Sciences of the Czech Republic and the Czech Herpetological Society are the host organization. The official language of the Congress will be English.

Contacts: For scientific aspects (programme, abstracts, professional field excursions, collecting permits, etc.): Zbyněk Roček, Department of Paleontology, Geological Institute, Academy of Sciences, Rozvojová 135, 165 00 Praha 6- Suchdol, Czech Republic. Tel.: (++ 42-2) 24 31 14 21; Fax: (++42 2) 24 31 15 78; email: rocek @gli.cas.cz.

For Technical aspects (registration fees, transportation, accommodation, accompanying member programme, post-congress tours, conditions for commercial activities, general inquiries, tours and excursions): Czech Medical Association J. E. Purkyně, Congress Department, P.O. Box 88, Sokolská 31, 120 26 Praha 2, Czech Republic. Tel.: (++ 42 2) 29 68 89, 297271; Fax: (++ 42 2) 29 4610, 24 216836.

SECOND INTERNATIONAL CONFERENCE ON THE BIOLOGY AND CONSERVATION OF THE SOUTH ASIAN REPTILES AND AMPHIBIANS.
Peradeniya, Sri Lanka, 1-5 August, 1996

Organized by the Amphibia and Reptile Research Organization of Sri Lanka, IUCN/SSC South Asian Reptile and Amphibian Specialist Group, University of Peradeniya, Department of Wildlife Conservation, Government of Sri Lanka, the Conference will be focussed on the biology and conservation of the south Asian herpetofauna. There will be opportunities for both spoken and poster papers, and a prize for the best student paper. Field trips will include visits to Sinharaja, Giritale and forests in and around Kandy (the type localities of some of Edward Taylor's new species), as well as visits to the Temple of the Tooth, in Kandy. The international airport is at Kattunayake, near Colombo (about 3 hours drive from the Conference venue). Abstracts are due by December 31, 1995.

For details contact: Mr. Anslem De Silva, Conference Director, Faculty of Medicine, University of Peradeniya, Peradeniya, Sri Lanka. Tel.: (+08) 88130. Fax: (+08) 32572.